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The Intrusion of Engine Exhaust Into the Passenger Areas of Recreational Power Boats

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Lawrence F. Simeone

**Research and Special Programs Administration
John A. Volpe National Transportation Systems Center
Cambridge, MA 02142-1093**

**Final Report
July 1991**

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PREFACE

Tests were run to measure the concentrations of carbon monoxide that accumulate in the passenger spaces of two recreational power boats during routine cruising operations. Results indicate that during certain phases of operation, carbon monoxide from the exhaust of the primary propulsion engines of the power boats can intrude into passenger spaces. The carbon monoxide can build up to significantly high levels to pose a health and safety threat to power boat passengers and crew. The accumulation of carbon monoxide in the passenger spaces during operation was closely related to the characteristics of the air flow about the boat (combination of boat speed wind and true wind). The boats tested were twin-engined cruisers with engine exhaust exits located on the sides of the boat at the water line.

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METRIC / ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
 1 foot (ft) = 30 centimeters (cm)
 1 yard (yd) = 0.9 meter (m)
 1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
 1 square foot (sq ft, ft²) = 0.09 square meter (m²)
 1 square yard (sq yd, yd²) = 0.8 square meter (m²)
 1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
 1 acre = 0.4 hectares (ha) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
 1 pound (lb) = .45 kilogram (kg)
 1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
 1 tablespoon (tbsp) = 15 milliliters (ml)
 1 fluid ounce (fl oz) = 30 milliliters (ml)
 1 cup (c) = 0.24 liter (l)
 1 pint (pt) = 0.47 liter (l)
 1 quart (qt) = 0.96 liter (l)
 1 gallon (gal) = 3.8 liters (l)
 1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
 1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

$$[(x - 32) (5/9)] ^\circ\text{F} = y ^\circ\text{C}$$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
 1 centimeter (cm) = 0.4 inch (in)
 1 meter (m) = 3.3 feet (ft)
 1 meter (m) = 1.1 yards (yd)
 1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
 1 square meter (m²) = 1.2 square yards (sq yd, yd²)
 1 square kilometer (km²) = 0.4 square mile (sq mi, mi²)
 1 hectare (ha) = 10,000 square meters (m²) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
 1 kilogram (kg) = 2.2 pounds (lb)
 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

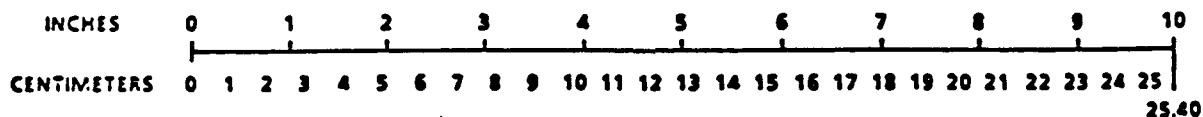
VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
 1 liter (l) = 2.1 pints (pt)
 1 liter (l) = 1.06 quarts (qt)
 1 liter (l) = 0.26 gallon (gal)
 1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
 1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

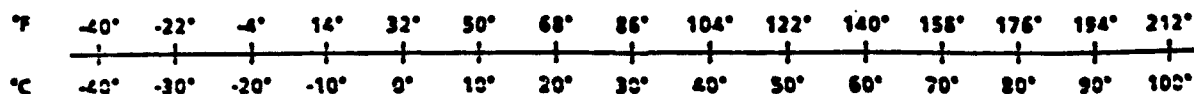
TEMPERATURE (EXACT)

$$[(9/5)y + 32] ^\circ\text{C} = x ^\circ\text{F}$$

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1. BACKGROUND AND OBJECTIVE

Incidents reported to the Coast Guard have identified a potential safety problem for recreational power boaters. It has been observed that exhaust gases from power boat primary propulsion engines can enter the cabin areas of the boats while they are underway. The exhaust gases of gasoline engines include a significant concentration of carbon monoxide (CO), an odorless, tasteless, and highly toxic gas. The accumulation of carbon monoxide in the cabins and passenger areas of power boats poses a serious health and safety threat to power boat passengers and crew. Exhaust gas contamination has precipitated a number of incidents of sickness and even a few fatalities annually among recreational power boaters.

The objective of this project is to obtain and analyze data on the intrusion of carbon monoxide in gasoline powered recreational power boats. The aim of the test program is to assess the seriousness of the problem and to investigate the mechanisms that exacerbate exhaust gas intrusion into the passenger areas.

2. APPROACH

The approach of the test program was to operate a recreational power boat at routine speeds and loads while monitoring and recording levels of carbon monoxide concentration in the cabin and other passenger areas of the boat. It is expected that as the boat moves through the air it creates a turbulent flow field; this flow field results in separated flow towards the rear of the boat. The separated flow creates a low-pressure area at the rear of the boat which causes exhaust gases to migrate into the boat as the exhaust mixes with the turbulent high-pressure free airstream. In these tests, all forward cabin hatches were closed off in order to ensure a low-pressure regime within the cabin and the rear entrance way was left open to allow for exhaust gas intrusion. In addition to carbon monoxide concentration measurements, free airflow about the boat was also monitored to provide a basis for estimating the influence of changes in the flow field on the resulting buildup of carbon monoxide.

Carbon monoxide test instrumentation consisted of National Dräger personal toxic gas monitors. The units are diffusion driven electrochemical cells which measure and record concentrations at 1-minute intervals. Four units were employed and placed at various locations on board the boat. Airflow about the boat was measured with a vane anemometer which was installed so that it measured free stream airflow. The anemometer was oriented forward and measured boat apparent head wind. (The vane anemometer did not measure negative wind; in instances of wind reversal the instrument produced a negative potential but it did not quantize the wind reversal.) Environmental instrumentation also included ambient temperature, humidity, and barometric pressure.

3. BOAT TESTS

3.1 BOSTON HARBOR BOAT TESTS

3.1.1 Test Conditions

Tests were run in Boston Harbor and offshore in Massachusetts Bay on August 25, 1990. The test boat was a 40-foot double cabin cruiser equipped with twin 454 CID engines with exhaust exits located on each side of the boat approximately 10 feet from the stern. Sensors were placed in the center of the forward cabin, on the aft deck at the transom, and at the topside control station. A fourth sensor was hand carried about the boat to record specific areas of interest and to serve as a back-up for the other sensors. All cabin hatches were closed except for the rear entrance way.

Boat operation consisted of the following identifiable segments:

(1) 09:47-10:50 - Cold start cruise from the Pleasant Point Yacht Club through the Boston Inner and Outer Harbors to Massachusetts Bay east of Deer Island Light (after some low-speed maneuvering in the yacht basin, a steady-state cruise at an engine speed of 2800 RPM for approximately 50 minutes).

(2) 10:57-12:14 - Eight test runs at varying speeds and head wind conditions in Massachusetts Bay: four high-speed runs at 3500 RPM both into the wind and away from the wind (7 minutes each) and four cruise runs at 2800 RPM both into the wind and away from the wind (7 minutes each).

(3) 12:16-12:46 - Cruise from Massachusetts Bay southeasterly to Dorchester Bay at 2800 RPM for approximately 30 minutes (mostly downwind).

(4) 14:30-14:55 - Two cruise runs, each in opposite directions in Dorchester Bay (8 minutes each) at 3000 RPM.

Weather was a solid overcast sky with an 8 to 10 knot wind blowing fairly steady out of the northeast. The wind dropped off in the afternoon. Temperature ranged from 69°F to 72°F, with relative humidity at 85% to 98%. Barometric pressure was steady at 30.08 inches of mercury.

3.1.2 Test Results

Data from the sensor in the cabin and the sensor on the rear deck near the transom provided the basis for the results discussed here. The helmsman station sensor was on the flying bridge which was awash with fresh air from the open windshield. It provided little useful information; the fourth sensor was handheld and served as a backup to the other sensors.

Some of the environmental and airflow data was lost. Environmental and airflow data for the cold start cruise out of the harbor and the eight test runs offshore was lost when the environmental data logger failed to log data. Measurement capacity remained unaffected; it is thought that a logger programming error or interference induced by boat radio transmissions turned the logging function off which went unnoticed until late in the morning. Subsequent runs in the afternoon were successfully logged without incident (radio transmissions were curtailed). The major data loss was the apparent head wind data during the cruise out of the harbor. Airflow data for the offshore test runs were reconstructed from similar runs and handwritten notes. The carbon monoxide sensors operated successfully throughout the test day without incident.

Results indicate that carbon monoxide accumulates in the cabin area of recreational power boats and these concentrations can often approach toxic levels. The two relatively long cruise runs (segments #1 & #3) saw a buildup of carbon monoxide in the cabin at a rate of almost 1 ppm (parts per million) per minute. The first run (cold start run out of the harbor) was averaging 56 ppm in the cabin after an hour of running and the second run (cruise to Dorchester Bay from offshore) was averaging 28 ppm after 30 minutes of cruise - both runs were run at an engine speed of 2800 RPM.

The high-speed test runs performed offshore proved to be too short to allow significant accumulation of CO in the cabin. The 7-minute test runs were not long enough to establish stabilized exhaust gas concentrations. Data from the high-speed runs into the wind where boat head wind averaged 29 knots did show a definite trend however. Both runs showed significant levels of CO in the cabin (22 and 10 ppm) at the beginning of the runs and no measurable concentration at the end of the run. This appears to indicate the importance of airflow about the boat and subsequent exhaust gas concentrations in the cabin. The suggestion here is that at high airflow rates, in addition to increased exhaust gas dilution potential, flow separation at the rear of the boat and subsequent turbulent mixing of the exhaust streams occurs further aft of the boat inhibiting migration of the exhaust gases into the cabin. High-speed runs with the wind where the airflow over the boat averaged only 7 knots showed stabilized concentrations over the test run and no apparent dilution of the CO concentration in the cabin. The cruise test runs performed offshore were also too short to establish stabilized concentrations of exhaust gas in the cabin.

The cruise test runs in Dorchester Bay, however, did show significantly higher concentrations of CO in the cabin than what would have been expected from the results of the offshore cruise runs, (an average of 10 ppm CO for the offshore runs versus an average 28 ppm for the Dorchester Bay runs).

The Dorchester Bay runs were tests run with the engine hull side air inlet vents blocked off. The initial analysis was that blockage of the vents had caused the engines to run rich with a subsequent increase in CO emissions. However, differential pressure measurements between the engine space and the ambient atmosphere showed no evidence that the engines were starved for air (a drop in engine compartment air pressure would be expected if insufficient air was available). It was noted that for safety reasons the engine compartment blower vents had not been blocked off. These vents, approximately 4 inches in diameter, could provide more than enough air to supply the engines at the nominal cruise speed at which the boat was operating. The airflow data, however, showed a drop in ambient wind. Head winds offshore for the cruise runs were 24 knots into the wind and 3 knots off the wind. Average head-wind data for the Dorchester Bay runs were 12 knots and 15 knots, thus indicating a change in ambient wind conditions. It is felt that this change in airflow about the boat is the reason for the increase in CO concentrations in the boat cabin. That is, at the airflow velocities seen during the Dorchester Bay runs, turbulent mixing of the exhaust streams occurred in closer proximity to the rear of the boat with a subsequent migration of contaminated air into the boat. Test data for the entire test day is tabulated chronologically in Appendix A.

3.2 CHESAPEAKE BAY BOAT TESTS

3.2.1 Test Conditions

The second series of tests were run on Chesapeake Bay south of Annapolis, Maryland. The test boat was a 34-foot Silverton sedan cruiser equipped with twin 302 CID engines with exhaust exits located on each side of the boat approximately 6 feet from the stern and at the waterline. Sensors were placed at two areas in the cabin: at the extreme forward cabin (forepeak sensor) and at midways in the cabin at the below deck control station (cabin control station sensor). A third sensor was placed on the rear deck at the transom (transom sensor) and the fourth sensor was placed in the engine compartment (engine space sensor). All cabin hatches were closed except for the rear entrance way.

This series of tests concentrated on steady-state cruising. Test runs consisted of a steady cruise (engine speed of 2800 RPM, boat speed 14 to 17 knots) for approximately 30 to 40 minutes into the prevailing wind, then a return cruise with the wind. Four runs were performed - two morning runs, easterly and westerly and two afternoon runs, easterly and westerly. With the exception of the first run, which started in the bay outside Shady Side, MD, test runs ran in a straight line across the bay into the South River to the Route 2 overpass (and return).

1

The initial easterly run in the morning started at about 10:00 am and lasted until 10:30 am. However, a wind shift occurred at about 10:18 and the boat apparent head wind went abruptly from approximately 10 knots to 18 knots. Data from 10:18 on was thus incorporated into the subsequent westerly (upwind) test run which had averaged an apparent head wind speed of 18 knots.

Weather was sunny with some overcast around noon and clearing in the afternoon. A cold front moved through the area about 10:30 bringing a wind shift and 10 to 20 knot breezes. Wind picked up in the afternoon - boat head wind into the wind averaged 18 knots in the morning and 26 knots in the afternoon. Boat head wind for the downwind test runs averaged 11 knots in the morning and 9 knots in the afternoon. Temperature ranged from 66 °F to 52 °F and humidity was 22% to 60%. Barometric pressure was fairly steady at 30.10 inches of mercury.

3.2.2 Test Results

Of the four sensors, the CO sensor at the transom consistently recorded the highest concentrations and the sensor at the cabin control station consistently recorded the second highest readings. The forepeak and engine compartment sensors gave comparable readings and were alternately the third highest. Since the engine compartment sensor readings consistently lagged the transom CO concentrations and the transom sensor consistently recorded the highest concentrations, it is apparent that the source of the CO in the cabin was, as expected, from the exhaust stream mixing at the rear of the boat and entering through the open rear hatch. Engine compartment leakage was not a factor in CO contamination of the cabin.

Test results show a strong correlation with airflow about the boat. During the easterly downwind runs when the average boat head wind dropped to 9 and 11 knots, stabilized CO concentrations in the cabin at the cabin helmsman station dropped to 2 and 7 ppm (respectively). The westerly runs, with the boat heading into the wind, the average boat head wind picked up to 18 and 26 knots; CO concentrations at the cabin control station during these runs averaged 170 and 93 ppm. These are average stabilized concentrations over a 30- to 20-minute time period.

Note that the afternoon westerly run showed significantly lower concentrations than the morning westerly run. The major difference between the two runs was the increase in head wind for the afternoon runs. This corresponds with the data observed during the Boston Harbor tests where higher airflow about the boat mitigated exhaust gas migration into the boat due to a change in the turbulent flow field. It appears that there is a critical band of boat head wind speed in which exhaust gas intrusion is exacerbated. At speeds lower than this critical band, the side-mounted exhaust streams are sufficiently diluted and carried away from the back of the boat. At certain critical speeds, however, turbulent mixing appears to occur in closer proximity to the rear of the boat and

exhaust gases migrate freely into the boat. At speeds above this critical band, dilution of the exhaust gas output from the side-mounted exits is increased and flow separation at the rear of the boat is lengthened. Mixing of the exhaust streams occurs further aft and exhaust gas migration into the boat is inhibited. CO concentrations built up at a rate of almost 2 ppm/minute in the morning runs and about 1 ppm/minute in the afternoon. Table 3-1 summarizes the data from the four test runs (data presented is for stabilized concentrations during the test runs). Table 3-1 shows the average stabilized carbon monoxide concentrations found in the passenger areas of a 34-foot recreational power boat with side exhausts during a routine cruise at an engine speed of 2800 RPM.

Table 3-1. Average CO Concentrations in Passenger Spaces during Test Runs Performed in Chesapeake Bay

Test Run	Head Wind (knots)	Transom (ppm)	Helm (ppm)	Forepeak (ppm)	EngComp (ppm)
PM Easterly	9.4	6.6	2.2	2.1	4.6
AM Easterly	10.6	11.8	6.5	3.4	4.2
AM Westerly	20.2	272.1	170.6	141.7	103.0
PM Westerly	27.0	149.7	93.3	74.9	72.9

Test data for the entire test day is tabulated chronologically in Appendix B.

4. DISCUSSION OF RESULTS

Initial tests run in Boston Harbor in August established that significant levels of carbon monoxide can build up in the passenger and crew areas of power boats. A 40-foot twin engine double cabin cruiser with side exhausts developed carbon monoxide concentrations as high as 55 ppm in the cabin and a peak of 123 ppm CO on the rear deck passenger area near the transom. These are significant concentrations with respect to the recommended exposure limit of 50 ppm CO (* time weighted average for 8 hours). Intrusion mechanisms were not particularly evident, however. Several short test runs at various speeds and wind conditions did not provide sufficient conclusive data. Two cruise runs lasting 50 and 20 minutes, however, indicated a steady buildup of carbon monoxide within the cabin. The data showed an average buildup of almost 1 ppm per minute. This indicated that a steady cruise of 30 minutes or more would provide a more definitive indication of the conditions leading to an accumulation of carbon monoxide in the boat cabin and rear passenger areas.

A second series of tests were run in December on Chesapeake Bay south of Annapolis. This series of tests involved a similar boat, a 34-foot twin engine sedan cruiser with side exhausts. The Chesapeake Bay tests concentrated on steady-state cruise conditions. Boat speed was held constant at an engine speed of 2800 RPM. Test runs were made both into and away from the wind for a duration of 30 minutes or more. Results showed that under certain cruise conditions carbon monoxide in the cabin and passenger areas can build up to highly toxic levels. During one cruise, concentrations on the rear deck near the transom of the boat averaged 272 ppm CO for over 30 minutes.

The test results show that a health and safety problem exists for recreational power boaters. The intrusion of boat exhaust gases into the passenger spaces of recreational power boats poses a potential health threat to boat operators and passengers. The levels of carbon monoxide contamination found in the passenger areas of a typical recreational power boat during routine cruising under certain conditions can exceed the recommended doses specified by health authorities. In one instance, at the transom of a 34-foot sedan cruiser during a routine cruise into the wind, CO concentration exceeded 400 ppm. It is apparent that the potential exists for a serious health and safety problem for power boaters.

* The American Conference of Governmental Industrial Hygienists (ACGIH) recommends two limits for carbon monoxide exposure; Threshold Limit Value-Time Weighted Average: 50 ppm CO over 8 hours (TLV-TWA) and Threshold Limit Value-Short Term Exposure Limit: 400 ppm for 15 minutes in any 60-minute period not to exceed four times a day (TLV-STEL).

It should be noted that the tests reported here were limited to levels of carbon monoxide concentrations in the boat. Engine exhaust gas contains a number of constituents in addition to carbon monoxide; these include carbon dioxide, unburned hydrocarbons and oxides of nitrogen, all of which can impair performance and contribute to the health and safety problem for power boat operators and passengers.

The test data shows that exhaust gas intrusion is significantly affected by airflow about the boat. For the particular cases studied here, which involved boats with side-mounted exhausts, head wind speeds of 10 knots or less showed little or no accumulation of exhaust gases in the passenger areas. At speeds from 10 to 30 knots, however, exhaust gases accumulated at the rear of the boat and intruded into passenger spaces. For head wind speeds greater than 30 knots, the amount of exhaust gas intrusion was reduced by the change in the resulting airflow field and the increased dilution potential of the surrounding fast-moving airstream.

These observations on the effect of head wind on exhaust gas intrusion is confined to the particular boat geometries tested. Both boats in this study had exhaust exits on the side of the boat. This configuration tends to minimize the direct intrusion of exhaust gases into the boat. With side exhaust exits, the free airstream mixes with the exhaust, dilutes it, and carries it rearward away from the boat. For a significant range of airstream velocities, however, airflow characteristics about the boat allow turbulent mixing of the contaminated airstream at the rear open end of the boat with a consequent contamination of the boat's environment. As the airflow field about the boat changes, these contamination characteristics also change.

Boats with exhaust exits at the stern could exhibit significantly different characteristics. For example, during the Chesapeake Bay tests, a couple of instances occurred in the afternoon easterly run where the vane anemometer reversed direction momentarily indicating a following apparent wind. CO concentrations in the cabin and at the transom remained negligible during these times and the downwind easterly run exhibited very minor cabin contamination. For a boat with rear exhaust exits, however, reverse airflow about the boat would blow exhaust gases directly over the transom and into the boat.

5. CONCLUSIONS AND RECOMMENDATIONS

The results of the tests reported here indicate a potential health and safety problem for power boat operators and their passengers. Depending on the flow characteristics of air about the boat, significant concentrations of carbon monoxide and other exhaust gases can accumulate in and about the boat and present a serious health threat to passengers and crew. The results reported here are for cruisers with side-mounted exhaust exits.

Ostensively, side-mounted exhaust exits minimize the intrusion of exhaust gases in the rear of the boat. The free airstream passing along the side of the boat dilutes the exhaust and under most flow conditions carries the exhaust away from the boat. It has been shown here, however, that under certain head wind conditions exhaust gases can accumulate in the boat and pose a serious health and safety risk.

Boats with stern-mounted exhaust exits were not tested in this program because of time, cost, and availability considerations. It would seem reasonable to assume, however, that boats with rear-mounted exhaust exits would exhibit even worst characteristics since the boat shields the exhaust from dilution by the free airstream and in instances of a following wind, the airflow would simply blow the exhaust gas into the boat. Also, the engines of the boats tested in this program were in excellent tune and operated flawlessly. For boats with out-of-tune engines or air inlets or air filters that are restricted, carbon monoxide levels could easily be doubled or tripled.

Tests run here were pilot tests to establish the existence of a potential health and safety risk for power boat passengers and crew and to make a preliminary assessment of gas intrusion mechanisms. No mitigation schemes were attempted, such as closing of the rear hatchway or opening forward hatches to allow fresh air to purge the cabin and reduce the low-pressure area at the rear of the boat.

The following recommendations should be considered for any further testing of exhaust gas intrusion into recreational power boats:

(1) Test several different configurations of boats so that the general population of recreational boats is represented. As noted above, boats with stern-mounted exhaust configurations would exhibit significantly different air contamination characteristics than the boats tested in this study. Some boat configurations may be significantly worse than others.

(2) Use more extensive airflow monitoring instrumentation. The tests reported here used only one flow monitor which measured boat apparent head wind. More extensive instrumentation would include an apparent wind indicator (both direction and intensity) and other flow indicators to monitor the flow of air at the rear of the boat. Flow visualization schemes should also be considered to monitor the

characteristics of the mixing of the engine exhaust and the airflow about the boat.

(3) Investigate the effectiveness of mitigation schemes. Mitigation schemes could include the opening and/or closing of cabin hatches to minimize exhaust gas intrusion, the rerouting of engine exhaust exits, the use of air deflectors to reroute airflow about the boat, or the use of catalytic converters or other engine control schemes to reduce engine carbon monoxide production.

(4) Monitor engine exhaust gas output and other engine parameters to verify source characteristics.

(5) Include different engine operating conditions such as trolling speeds, idling, high-speed runs, etc.

Figure 5-1 demonstrates stabilized time weighted average concentrations of engine exhaust carbon monoxide found in various spaces onboard a 34-foot recreational power boat as a function of apparent boat head wind during routine cruising conditions with an engine speed of 2800 RPM.

Average Carbon Monoxide Concentrations Onboard a 34-Foot Recreational Power Boat
1984 34-foot Sedan Cruiser w/ Side Exhausts - Engine Speed 2800 RPM

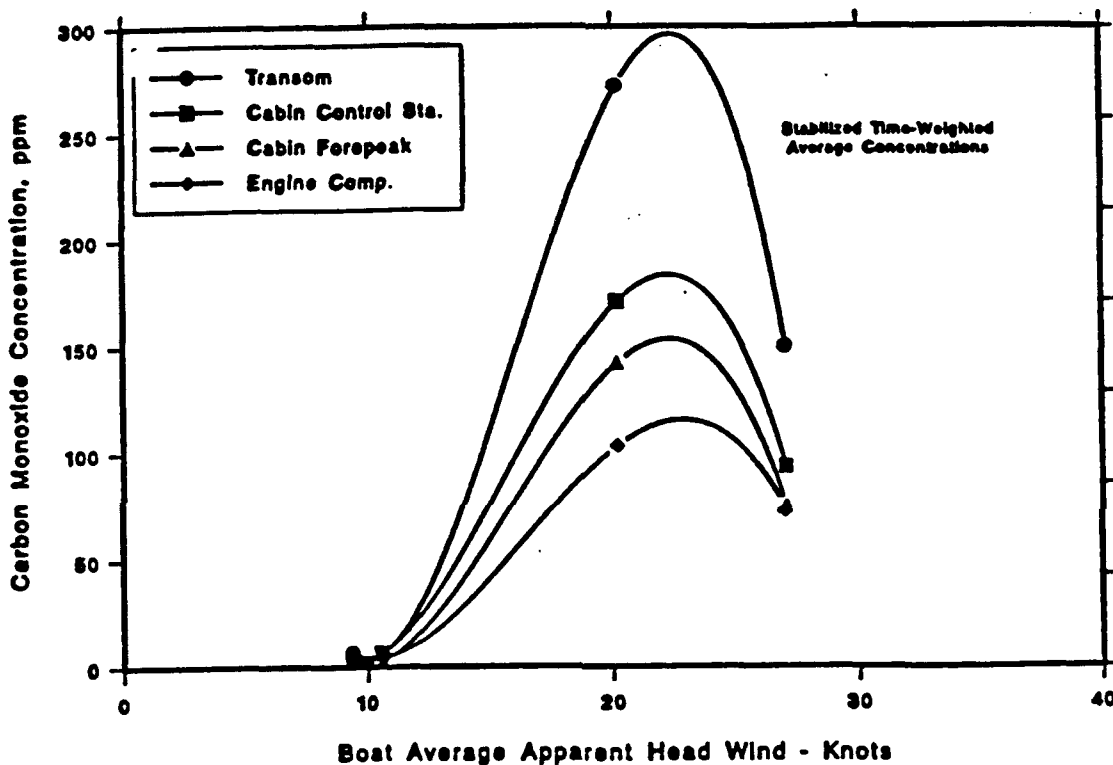


Figure 5-1. CO Concentrations in Passenger Spaces during Routine Boat Operation versus Boat Apparent Wind Speed

Figure 5-2 shows the Chesapeake Bay morning test run data concerning passenger space engine exhaust carbon monoxide contamination during a routine cruise with an engine speed of 2800 RPM.

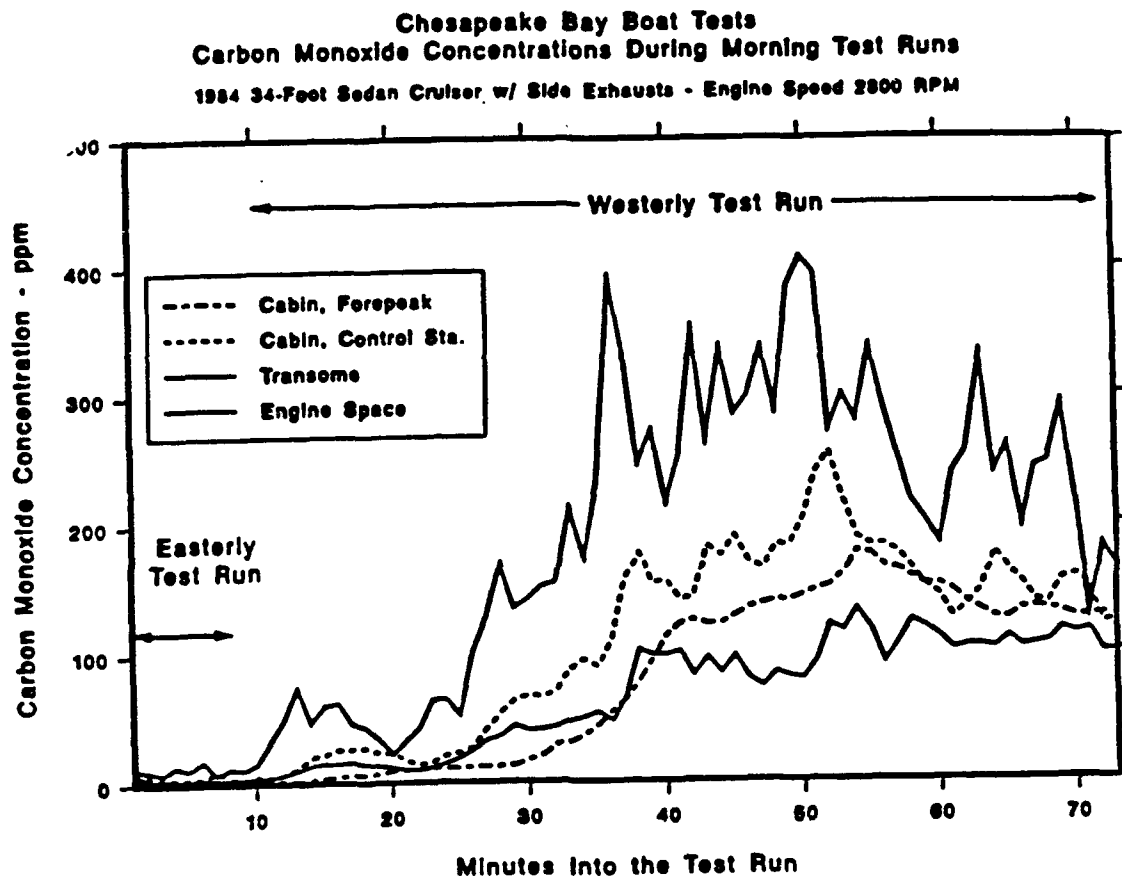


Figure 5-2. Chesapeake Bay Morning Test Run Data: Passenger Space CO Contamination during a Routine Cruise

Figure 5-3 shows the Chesapeake Bay morning test run data which involves boat apparent head wind during a routine cruise with an engine speed of 2800 RPM.

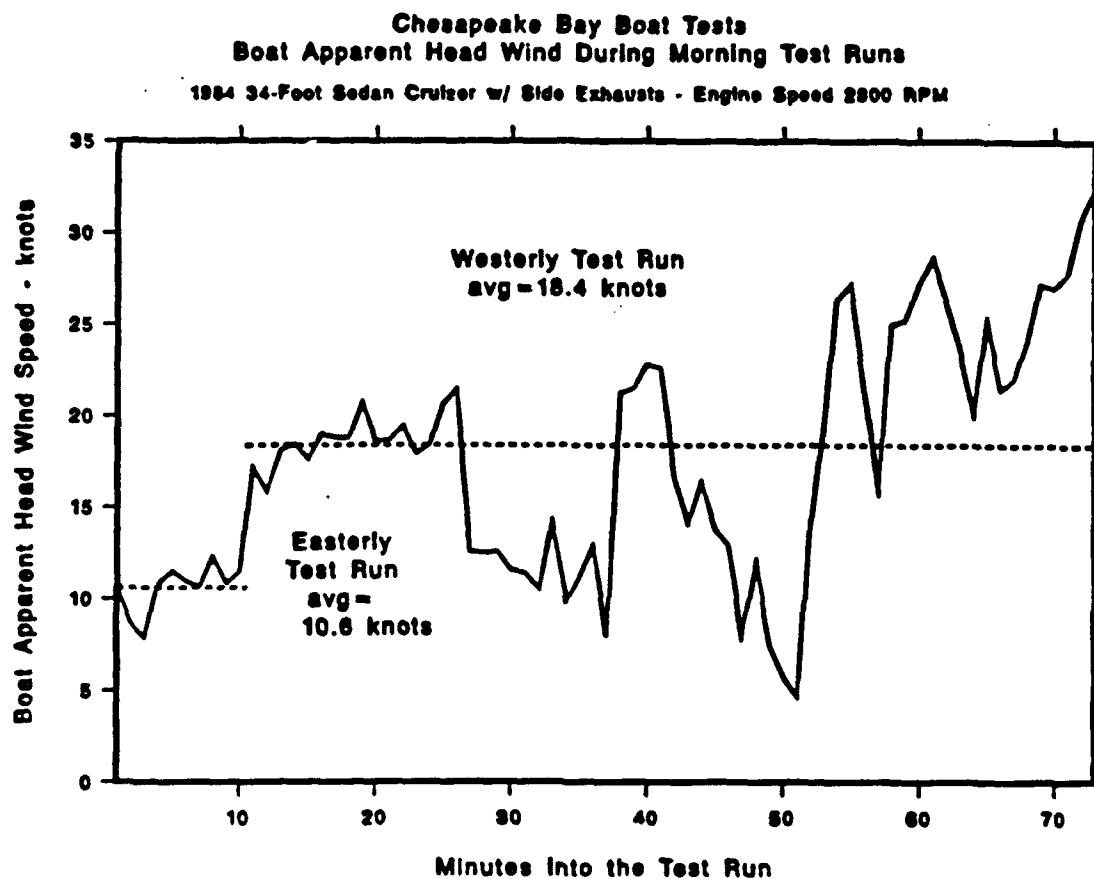


Figure 5-3. Chesapeake Bay Morning Test Run Data: Apparent Boat Wind Speed

Figure 5-4 shows the Chesapeake Bay afternoon test run data which demonstrates passenger space engine exhaust carbon monoxide contamination during a routine cruise, with an engine speed of 2800 RPM.

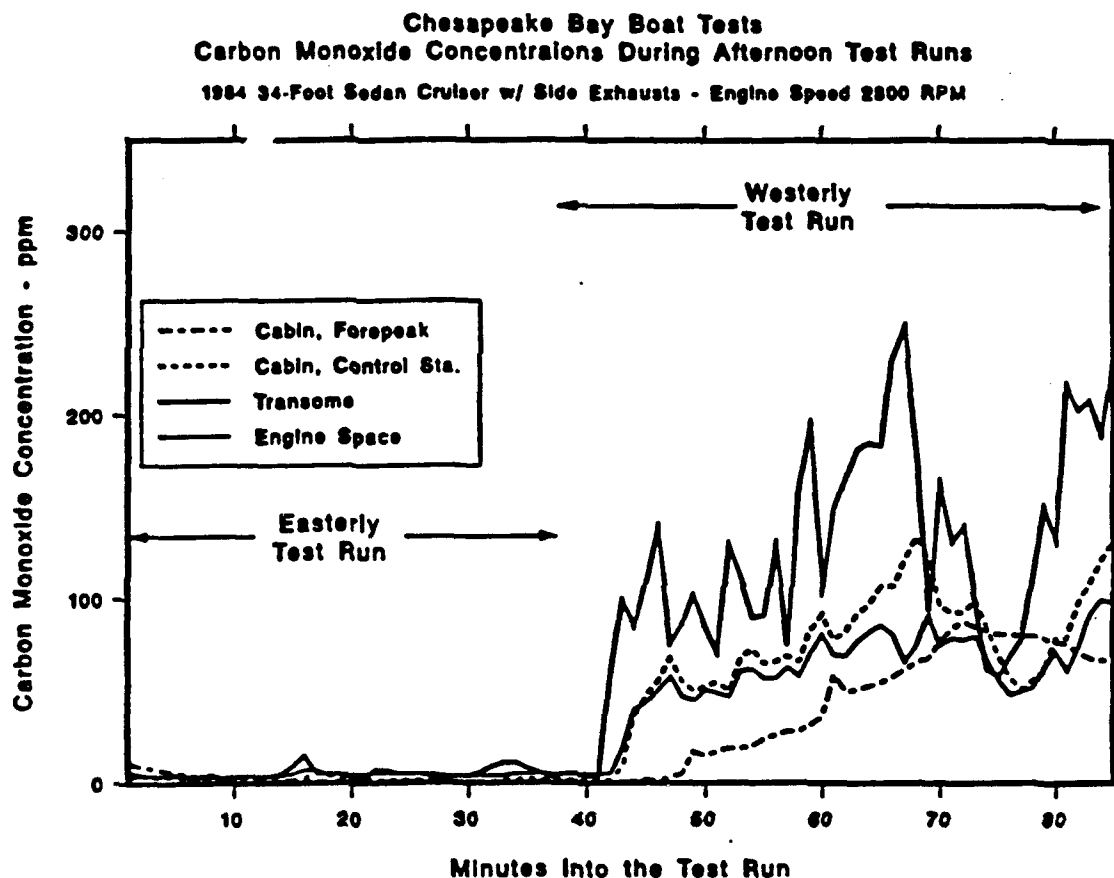


Figure 5-4. Chesapeake Bay Afternoon Test Run Data: Passenger Space CO Contamination during a Routine Cruise

1

Figure 5-5 shows the Chesapeake Bay afternoon test run data involving boat apparent head wind during a routing cruise with an engine speed of 2800 RPM.

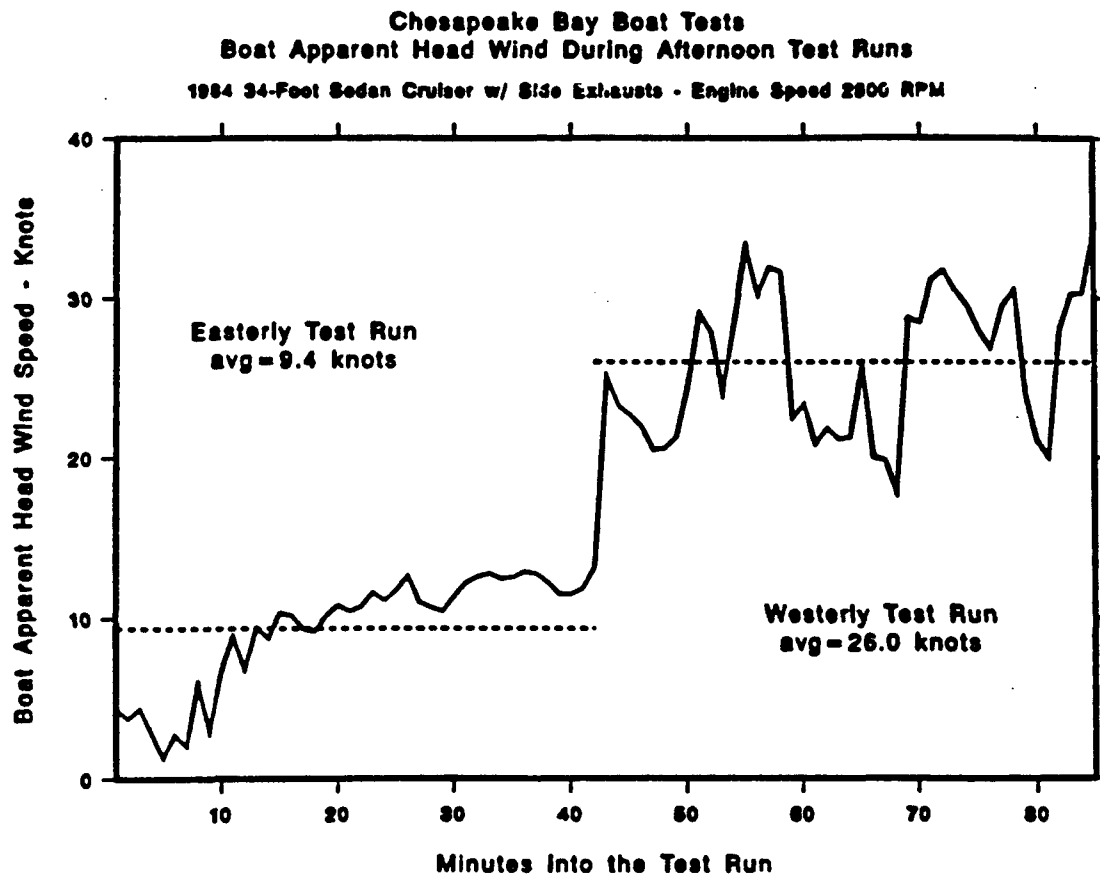


Figure 5-5. Chesapeake Bay Afternoon Test Run Data: Apparent Boat Wind Speed

Figure 5-6 demonstrates the effects of carbon monoxide exposure on blood carboxyl-hemoglobin levels (from Peterson, J.E., Stewart, R.D.: THE ABSORPTION AND ELIMINATION OF CARBON MONOXIDE BY INACTIVE YOUNG MEN (1970). Arch. Environ. Health 21:165-171).

Effects of Carbon Monoxide Exposure on Blood Carboxy-Hemoglobin Levels

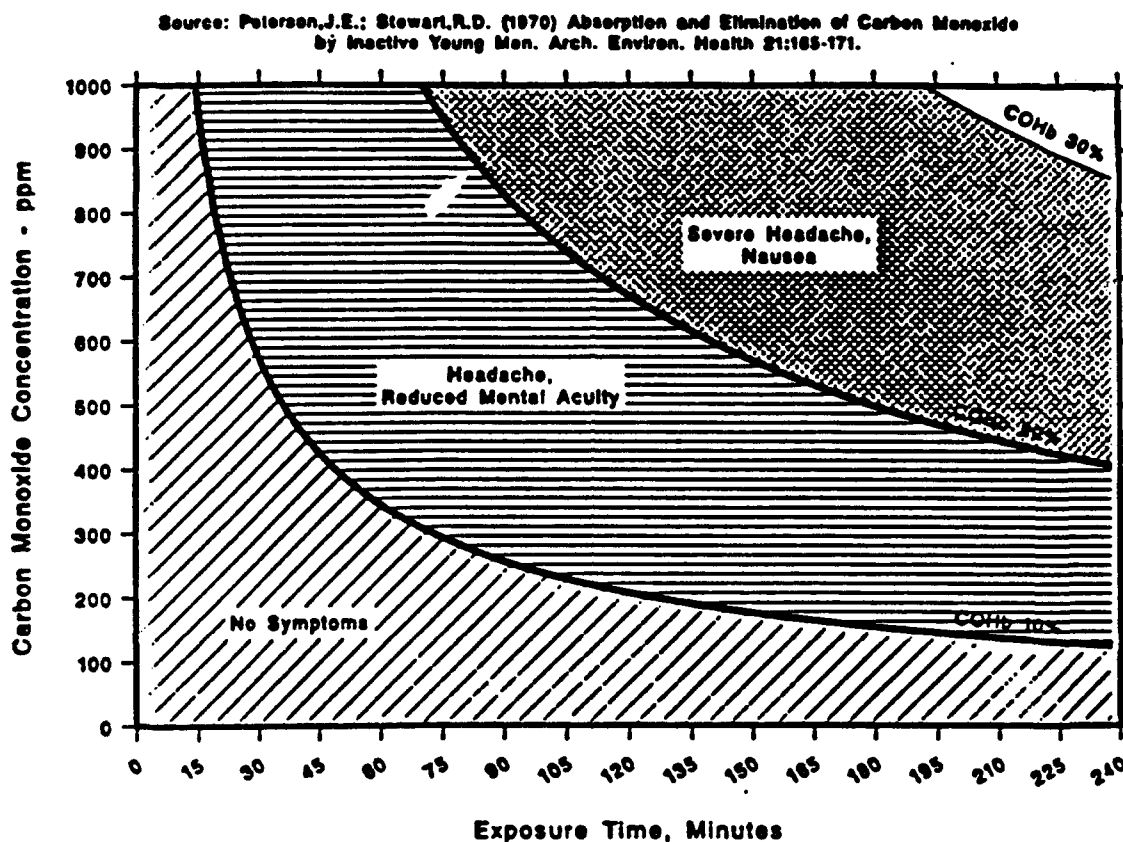


Figure 5-6. The Effects of Carbon Monoxide Exposure on Blood Carboxyl-Hemoglobin Levels

APPENDIX A

Boston Harbor Boat Test Data

Coast Guard Boat Tests - Boston Harbor - Saturday, August 25, 1990

Time of Day	Temp (F)	Rel Hum (%)	Baro Press (in Hg)	Head Wind (knots)	CO1 ppm (hand)	CO2 ppm (stern)	CO3 ppm (helm)	CO4 ppm (cabin)	Remarks
8:00:00	0	1	1	0	NOTES: Weather service reports winds out of the Northeast at 8 to 10 knots. Solid overcast, winds steady, Barometric pressure 30.08 in Hg (steady). Temperature range: 69.7 - 72.1 F, humidity range: 85.1% - 98.5% RH.
8:01:00	.	.	.	.	0	1	1	0
8:02:00	.	.	.	.	0	1	1	0
8:03:00	.	.	.	.	0	1	1	0
8:04:00	0	1	0	0	Test Boat: 40' Sliverton Double Cabin Cruiser Liberty III, #403208 Donald Gray, Owner/Helmsman Peter Dunn, Crew/Helmsman
8:05:00	.	.	.	.	0	0	0	0
8:06:00	.	.	.	.	0	0	0	0
8:07:00	.	.	.	.	0	1	0	0
8:08:00	0	1	1	0	Boat equipped with twin 454-CID GM engines: Exhaust exits are on the port and starboard side of the boat approx 10 feet from the stern, approx 12 feet apart, and located at the waterline.
8:09:00	.	.	.	.	0	1	1	0
8:10:00	.	.	.	.	0	1	0	0
8:11:00	.	.	.	.	0	1	1	1
8:12:00	0	1	1	.	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:13:00	.	.	.	.	0	1	0	0
8:14:00	.	.	.	.	0	0	0	0
8:15:00	.	.	.	.	0	0	0	0
8:16:00	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:17:00	.	.	.	.	0	0	0	0
8:18:00	.	.	.	.	0	0	0	0
8:19:00	.	.	.	.	0	0	0	0
8:20:00	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:21:00	.	.	.	.	0	0	0	0
8:22:00	.	.	.	.	0	0	0	0
8:23:00	.	.	.	.	0	0	0	0
8:24:00	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:25:00	.	.	.	.	0	0	0	0
8:26:00	.	.	.	.	0	0	0	0
8:27:00	.	.	.	.	0	0	0	0
8:28:00	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:29:00	.	.	.	.	0	0	0	0
8:30:00	.	.	.	.	0	0	-1	0
8:30:30	72.1	86.6	30.08	1.03	.	.	-1	0	
8:31:01	72.1	86.7	30.08	0.87	0	.	-1	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:31:31	72.1	86.9	30.08	1.14	0	.	-1	0	
8:32:01	72.0	87.1	30.08	1.08	0	0	-1	0	
8:32:31	72.0	87.1	30.08	1.18	0	0	0	0	
8:33:01	72.0	87.3	30.08	2.03	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:33:31	72.0	87.4	30.08	0.00	0	0	0	0	
8:34:02	72.0	87.6	30.08	1.29	0	0	0	0	
8:34:31	71.9	87.8	30.08	1.16	0	0	0	0	
8:35:01	71.9	88.0	30.08	0.00	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:35:32	71.9	88.2	30.08	1.64	0	0	0	0	
8:36:00	71.9	88.3	30.08	0.00	0	0	0	0	
8:37:00	.	.	.	.	0	0	0	0
8:38:00	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:39:00	.	.	.	.	0	0	0	0
8:40:00	.	.	.	.	0	0	1	0
8:41:00	.	.	.	.	0	0	0	0
8:42:00	0	0	0	0	Sensor CO1 - Hand held, moved about boat. CO2 - Located in stern at transome, approx 85" above, 90" aft, and 68" inboard of both exhausts. CO3 - Located at topside control station 19" left of boat centerline (wheel at centerline of boat) 93" fwd of exhaust exits and approx 180" above exhaust exits. CO4 - Located in cabin at centerline of boat, approx 177" fwd of exhaust exits; single open hatchway at rear of cabin.
8:43:00	.	.	.	.	0	-1	0	0
8:44:00	.	.	.	.	0	-1	0	0
8:45:00	.	.	.	.	0	-1	-1	0

19:46:00	.	.	.	.	0	-1	0	0	Engine Start-up
19:47:00	.	.	.	.	0	3	0	0	
19:48:00	.	.	.	.	5	10	2	1	
19:49:00	.	.	.	.	2	6	8	3	
19:50:00	.	.	.	.	12	8	9	3	Boat traffic nearby - still tied up, idling
19:51:00	.	.	.	.	32	6	27	3	
19:52:00	.	.	.	.	8	25	41	3	
19:53:00	.	.	.	.	0	2	25	8	
19:54:00	.	.	.	.	42	19	17	7	
19:55:00	.	.	.	.	5	3	35	10	Place differential press trans in cabin
19:56:00	.	.	.	.	12	22	0	13	
19:57:00	.	.	.	.	1	3	8	11	
19:58:00	.	.	.	.	9	2	1	11	
19:59:00	.	.	.	.	15	33	6	9	
10:00:00	.	.	.	.	10	22	10	11	
10:01:00	.	.	.	.	9	10	11	12	
10:02:00	.	.	.	.	8	9	4	12	Port beam wind
10:03:00	.	.	.	.	72	38	17	12	In channel along Logan airport - South heading
10:04:00	.	.	.	.	107	13	35	17	COL held over approx 8 directly over exhaust
10:05:00	.	.	.	.	27	2	34	17	
10:06:00	.	.	.	.	20	24	75	25	
10:07:00	.	.	.	.	20	14	48	29	
10:08:00	.	.	.	.	11	6	20	27	
10:09:00	.	.	.	.	14	22	10	24	
10:10:00	.	.	.	.	16	11	14	22	
10:11:00	.	.	.	.	10	12	29	21	
10:12:00	.	.	.	.	22	32	31	21	
10:13:00	.	.	.	.	23	16	55	25	
10:14:00	.	.	.	.	23	25	56	28	
10:15:00	.	.	.	.	5	20	22	32	
10:16:00	.	.	.	.	0	7	2	32	Inner harbor, speed at 2800 RPM - Head Southwest
10:17:00	.	.	.	.	7	14	1	27	
10:18:00	.	.	.	.	3	7	4	22	
10:19:00	.	.	.	.	11	6	2	18	COL inside cabin area
10:20:00	.	.	.	.	16	4	4	19	
10:21:00	.	.	.	.	15	7	4	18	
10:22:00	.	.	.	.	3	3	4	18	
10:23:00	.	.	.	.	14	21	2	17	Enter outer harbor - Head Northeast
10:24:00	.	.	.	.	24	37	16	23	
10:25:00	.	.	.	.	25	33	21	37	
10:26:00	.	.	.	.	28	43	21	45	COL at helmsman station
10:27:00	.	.	.	.	49	50	29	59	
10:28:00	.	.	.	.	22	97	21	63	
10:29:00	.	.	.	.	14	104	21	55	
10:30:00	.	.	.	.	11	71	14	47	
10:31:00	.	.	.	.	8	62	11	41	
10:32:00	.	.	.	.	17	70	9	34	COL in cabin area (middle of cabin 5' aft of sensor)
10:33:00	.	.	.	.	26	86	11	31	
10:34:00	.	.	.	.	30	101	14	31	
10:35:00	.	.	.	.	19	118	18	34	
10:36:00	.	.	.	.	7	95	20	39	Offshore - Easterly heading
10:37:00	.	.	.	.	16	91	14	37	
10:38:00	.	.	.	.	17	29	21	42	
10:39:00	.	.	.	.	17	34	20	45	
10:40:00	.	.	.	.	17	49	20	50	
10:41:00	.	.	.	.	16	138	23	53	COL at transome
10:42:00	.	.	.	.	51	117	24	55	COL in cabin; heading 90deg @ 2800 RPM
10:43:00	.	.	.	.	48	41	19	51	
10:44:00	.	.	.	.	43	48	23	53	
10:45:00	.	.	.	.	24	43	22	55	

1:46:00	.	.	.	.	32	51	20	56	
1:47:00	.	.	.	.	52	41	22	59	
1:48:00	.	.	.	.	24	50	27	60	
1:49:00	.	.	.	.	11	84	22	58	
1:50:00	.	.	.	.	10	101	17	50	
1:51:00	.	.	.	.	8	130	12	42	
1:52:00	.	.	.	.	6	52	13	38	
1:53:00	.	.	.	.	7	102	12	37	
1:54:00	.	.	.	.	2	16	9	32	
1:55:00	.	.	.	.	8	76	3	21	
1:56:00	.	.	.	.	10	76	10	19	
1:57:00	.	.	.	.	9	79	14	22	<--- Start High Speed Run: 3600 RPM @40deg (into wind)
1:58:00	.	.	.	.	0	19	8	20	<--- Apparent wind approx 29 knots
1:59:00	.	.	.	.	-1	1	0	8	<---
2:00:00	.	.	.	.	-1	1	0	3	<---
2:01:00	.	.	.	.	-1	1	0	2	<---
2:02:00	.	.	.	.	-1	1	0	1	<---
2:03:00	.	.	.	.	3	3	0	0	<--- End high speed run
2:04:00	.	.	.	.	16	99	7	4	CO2 at transome senses boat exhaust wake as boat t
2:05:00	.	.	.	.	9	17	13	17	Come to 220deg, medium speed to cool engines
2:06:00	.	.	.	.	2	3	10	17	<--- Start High Speed Run away from wind: 3600 RPM
2:07:00	.	.	.	.	0	13	1	16	<--- Apparent wind approx 7 knots, heading 220 deg.
2:08:00	.	.	.	.	1	10	0	12	<---
2:09:00	.	.	.	.	7	12	0	9	<---
2:10:00	.	.	.	.	7	23	0	8	<---
2:11:00	.	.	.	.	14	32	1	10	<---
2:12:00	.	.	.	.	0	33	1	13	<--- End high speed run
2:13:00	.	.	.	.	1	11	1	16	
2:14:00	.	.	.	.	16	22	3	16	
2:15:00	.	.	.	.	18	33	19	23	
2:16:00	.	.	.	.	6	39	22	34	<--- Start Cruise Speed Run into wind: 3000RPM @40deg
2:17:00	.	.	.	.	1	13	3	27	<--- Apparent wind approx 28 knots
2:18:00	.	.	.	.	0	6	2	16	<---
2:19:00	.	.	.	.	6	35	1	9	<---
2:20:00	.	.	.	.	7	66	8	11	<---
2:21:00	.	.	.	.	6	56	9	16	<---
2:22:00	.	.	.	.	12	13	6	16	<--- End Cruise Run
2:23:00	.	.	.	.	24	93	19	12	
2:24:00	.	.	.	.	5	19	21	17	<--- Start Cruise Run away from wind: 3000RPM @ 220deg
2:25:00	.	.	.	.	11	24	4	18	<--- Apparent wind approx 3 knots
2:26:00	.	.	.	.	10	10	2	16	<--- CO1 in cabin
2:27:00	.	.	.	.	7	7	1	13	<---
2:28:00	.	.	.	.	1	9	1	10	<---
2:29:00	.	.	.	.	1	9	1	10	<---
2:30:00	.	.	.	.	1	9	1	10	<--- End cruise run
2:31:00	.	.	.	.	9	17	3	9	
2:32:00	.	.	.	.	9	12	8	9	
2:33:00	.	.	.	.	0	3	10	10	
2:34:00	.	.	.	.	0	1	1	10	
2:35:00	.	.	.	.	2	2	0	6	
2:36:00	.	.	.	.	2	22	4	6	
2:37:00	.	.	.	.	0	13	2	8	<--- Start Cruise Run into wind: 3000RPM @ 36deg
2:38:00	.	.	.	.	0	3	1	4	<--- Apparent wind approx 24 knots.
2:39:00	.	.	.	.	0	4	1	2	<---
2:40:00	.	.	.	.	0	3	1	2	<---
2:41:00	.	.	.	.	0	6	1	2	<---
2:42:00	.	.	.	.	0	3	1	2	<---
2:43:00	.	.	.	.	1	14	1	2	<--- End cruise run
2:44:00	.	.	.	.	17	52	3	3	
2:45:00	.	.	.	.	7	8	19	-11	<--- Start Cruise Run away from wind: 3000RPM @ 220deg

1:46:00	.	.	.	.	1	8	7	11	← Apparent wind approx 3 knots
1:47:00	.	.	.	.	0	8	1	10	←
1:48:00	.	.	.	.	0	8	1	9	←
1:49:00	.	.	.	.	0	2	1	9	←
1:49:32	70.0	93.7	30.07	0.00	.	.	.	.	←
1:50:00	.	.	.	.	0	2	0	8	← End Cruise Run
1:51:01	70.2	93.2	30.08	0.00	0	3	1	7	
1:51:32	70.3	93.1	30.07	1.42	.	.	.	.
1:52:01	70.4	93.4	30.08	3.90	0	2	1	6	
1:52:31	70.7	93.5	30.07	18.77	.	.	.	.
1:53:01	70.9	92.4	30.07	9.13	12	23	2	4	
1:53:31	71.0	92.0	30.07	3.37	.	.	.	.
1:54:01	71.2	91.1	30.08	5.06	11	18	16	9	Helmsman smoking near CO1
1:54:31	71.3	90.2	30.08	5.83	.	.	.	.
1:55:01	71.4	89.6	30.08	1.03	19	14	14	10	
1:56:00	.	.	.	.	30	18	23	12	
1:57:00	.	.	.	.	34	14	37	13	
1:58:00	.	.	.	.	19	7	34	16	
1:59:00	.	.	.	.	17	8	22	14	
2:00:00	.	.	.	.	8	8	18	14	
2:01:00	.	.	.	.	3	10	6	14	
2:02:00	.	.	.	.	2	9	4	13	
2:02:31	73.1	87.6	30.08	4.54	.	.	.	.
2:03:01	73.1	85.6	30.08	3.53	5	7	2	13	
2:03:31	73.1	85.7	30.08	4.58	.	.	.	.
2:04:00	73.2	85.1	30.08	4.54	0	2	4	12	
2:04:31	73.3	85.2	30.08	2.36	.	.	.	.
2:05:01	73.1	85.5	30.08	1.88	2	3	1	12	
2:05:31	73.3	84.8	30.07	5.94	.	.	.	.
2:06:01	72.9	84.6	30.07	6.00	0	6	2	10	← Start High Speed Run away from wind: 3600RPM
2:06:30	72.7	86.0	30.08	4.08	.	.	.	.	← Heading 220 deg.
2:07:00	72.4	87.3	30.07	5.87	0	7	0	7	← Apparent wind avg 6.6 knots.
2:07:30	72.2	88.4	30.06	7.48	.	.	.	.	←
2:08:01	71.9	89.4	30.07	6.95	-1	6	0	4	←
2:08:30	71.7	90.1	30.06	5.86	.	.	.	.	←
2:09:00	71.5	90.5	30.07	7.54	-1	2	0	3	← Come to 220deg
2:09:30	71.3	91.1	30.07	1.36	.	.	.	.
2:10:00	71.2	92.5	30.07	20.26	10	20	0	2	
2:10:31	71.2	92.7	30.06	22.89	.	.	.	.
2:11:00	71.2	92.6	30.06	29.28	5	55	12	10	← Start High Speed Run into wind: 3600RPM @ 36deg
2:11:30	71.2	92.2	30.06	28.80	.	.	.	.	←
2:12:01	71.2	91.9	30.05	31.59	-1	0	3	11	← Apparent wind avg 29 knots
2:12:30	71.1	91.9	30.05	31.23	.	.	.	.	←
2:13:00	71.1	91.8	30.05	31.45	-1	1	0	4	←
2:13:31	71.0	91.7	30.05	32.35	.	.	.	.	←
2:14:00	71.0	91.7	30.06	23.53	0	1	0	2	← End High Speed Run
2:14:30	70.9	91.9	30.07	1.37	.	.	.	.
2:15:00	70.9	92.1	30.07	0.98	2	19	1	2	
2:15:30	70.9	92.0	30.07	1.11	.	.	.	.
2:16:01	70.8	92.2	30.07	1.03	5	22	2	4	Head towards Marina Bay for lunch break
2:16:31	70.8	92.0	30.07	1.40	.	.	.	.	Southeasterly heading
2:17:00	70.8	92.4	30.06	1.05	2	33	2	6	
2:17:30	70.8	92.4	30.08	0.00	.	.	.	.
2:18:01	70.8	92.7	30.07	1.03	0	6	2	9	
2:19:00	.	.	.	.	0	6	1	9	
2:20:00	.	.	.	.	1	24	1	9	
2:21:00	.	.	.	.	0	10	1	8	
2:22:00	.	.	.	.	0	2	1	9	
2:23:00	.	.	.	.	0	11	0	8	

24:00	.	.	.	.	0	13	1	8
25:00	.	.	.	.	0	2	1	8
26:00	.	.	.	.	0	6	0	7
27:00	.	.	.	.	0	10	0	6
28:00	.	.	.	.	0	9	0	7
29:00	.	.	.	.	0	17	0	7
30:00	.	.	.	.	0	24	1	7
31:00	.	.	.	.	0	27	1	9
32:00	.	.	.	.	0	32	2	11
33:00	.	.	.	.	1	45	1	12
34:00	.	.	.	.	0	39	1	16
35:00	.	.	.	.	0	29	1	20
36:00	.	.	.	.	1	60	1	22
37:00	.	.	.	.	0	51	2	23
38:00	.	.	.	.	1	45	1	24
39:00	.	.	.	.	1	60	2	28
40:00	.	.	.	.	0	42	1	29
41:00	.	.	.	.	1	47	1	29
42:00	.	.	.	.	1	50	2	28
43:00	.	.	.	.	1	32	1	29
44:00	.	.	.	.	1	30	1	28
45:00	.	.	.	.	0	27	1	27
46:00	.	.	.	.	0	21	1	24
47:00	.	.	.	.	2	25	1	23
48:00	.	.	.	.	1	19	3	22
49:00	.	.	.	.	1	34	2	21
50:00	.	.	.	.	0	9	1	22
51:00	.	.	.	.	0	17	1	21
52:00	.	.	.	.	1	45	1	19
53:00	.	.	.	.	1	24	2	19
54:00	.	.	.	.	0	20	1	19
55:00	.	.	.	.	1	21	1	19
56:00	.	.	.	.	3	38	1	18
57:00	.	.	.	.	7	18	3	19
57:31	69.8	98.2	30.09	1.62	1	11	7	18
58:01	69.9	97.9	30.09	1.39	14	3	2	16
59:00	.	.	.	.	1	3	16	16
00:00	.	.	.	.	0	1	1	17
01:00	.	.	.	.	0	7	1	16
02:00	.	.	.	.	-1	0	0	12
03:00	.	.	.	.	-1	0	-1	10
04:00	.	.	.	.	-1	0	-1	10
05:00	.	.	.	.	-1	0	-1	7
06:00	.	.	.	.	-1	0	-1	7
07:00	.	.	.	.	-1	0	-1	7
08:00	.	.	.	.	-1	0	-1	7
09:00	.	.	.	.	-1	0	-1	3
10:00	.	.	.	.	-1	0	-1	3
11:00	.	.	.	.	-1	0	-1	2
12:00	.	.	.	.	-1	0	-1	2
13:00	.	.	.	.	-1	0	0	2
14:00	.	.	.	.	0	0	0	2
15:00	.	.	.	.	0	0	0	2
16:00	.	.	.	.	-1	0	0	2
17:00	.	.	.	.	0	0	0	2
18:00	.	.	.	.	-1	0	0	2
19:00	.	.	.	.	-1	0	0	2
20:00	.	.	.	.	-1	0	0	2
21:00	.	.	.	.	-1	0	0	2
22:00	.	.	.	.	-1	0	0	2

In marina area low speed maneuvering

Engine off, break for lunch at Marina Bay
(Dorchester Bay)

13:23:00	.	.	.	.	-1	0	0	2
13:24:00	.	.	.	.	-1	0	0	2
13:25:00	.	.	.	.	-1	0	0	2
13:26:00	.	.	.	.	0	0	0	2
13:27:00	.	.	.	.	0	2	0	1
13:28:00	.	.	.	.	0	1	1	2
13:29:00	.	.	.	.	-1	0	0	2
13:30:00	.	.	.	.	-1	0	0	2
13:31:00	.	.	.	.	0	1	0	2
13:32:00	.	.	.	.	0	1	0	1
13:33:00	.	.	.	.	0	1	0	1
13:34:00	.	.	.	.	0	1	0	2
13:35:00	.	.	.	.	-1	0	0	1
13:36:00	.	.	.	.	-1	0	0	1
13:37:00	.	.	.	.	-1	0	-1	1
13:38:00	.	.	.	.	-1	0	-1	1
13:39:00	.	.	.	.	-1	0	-1	1
13:40:00	.	.	.	.	-1	0	-1	1
13:41:00	.	.	.	.	-1	0	-1	1
13:42:00	.	.	.	.	-1	0	-1	1
13:43:00	.	.	.	.	-1	0	-1	1
13:44:00	.	.	.	.	-1	0	-1	1
13:45:00	.	.	.	.	-1	0	-1	1
13:46:00	.	.	.	.	-1	0	-1	1
13:47:00	.	.	.	.	-1	0	0	1
13:48:00	.	.	.	.	-1	0	0	1
13:49:00	.	.	.	.	-1	0	-1	1
13:50:00	.	.	.	.	-1	0	-1	0
13:51:00	.	.	.	.	-1	0	0	0
13:52:00	.	.	.	.	0	0	-1	0
13:53:00	.	.	.	.	0	1	0	0
13:54:00	.	.	.	.	-1	0	1	1
13:55:00	.	.	.	.	0	0	0	1
13:56:00	.	.	.	.	0	0	0	1
13:57:00	.	.	.	.	-1	0	0	1
13:58:00	.	.	.	.	-1	0	-1	1
13:59:00	.	.	.	.	-1	0	-1	1
14:00:00	.	.	.	.	-1	0	0	0
14:01:00	.	.	.	.	0	0	0	1
14:02:00	.	.	.	.	-1	0	0	1
14:03:00	.	.	.	.	-1	0	-1	1
14:04:00	.	.	.	.	-1	0	0	1
14:05:00	.	.	.	.	-1	0	-1	0
14:06:00	.	.	.	.	-1	0	0	0
14:07:00	.	.	.	.	-1	0	-1	0
14:08:00	.	.	.	.	-1	0	-1	0
14:09:00	.	.	.	.	-1	0	-1	0
14:10:00	.	.	.	.	-1	0	-1	0
14:11:00	.	.	.	.	-1	0	-1	0
14:12:00	.	.	.	.	-1	0	0	0
14:13:00	.	.	.	.	-1	0	-1	0
14:14:00	.	.	.	.	-1	0	-1	0
14:15:00	.	.	.	.	-1	0	-1	0
14:16:00	.	.	.	.	-1	0	-1	0
14:17:00	.	.	.	.	-1	0	0	0
14:18:00	.	.	.	.	6	6	0	0
14:19:00	.	.	.	.	5	13	8	1
14:20:00	.	.	.	.	1	22	3	2
14:21:00	.	.	.	.	2	10	2	6
14:22:00	.	.	.	.	1	8	2	6

Restart engines with intake vents blocked
(Blower vents open)

1:23:00	.	.	.	.	0	11	1	6	
1:24:00	.	.	.	.	0	2	1	6	Low speed in marina
1:24:30	71.6	92.9	30.09	7.04					
1:25:00	71.6	93.1	30.09	7.13	0	4	0	4	Engine space blower off
1:25:30	71.6	93.2	30.09	11.04					
1:26:00	71.5	93.0	30.09	12.00	0	10	0	4	
1:26:30	71.5	93.4	30.09	11.56					
1:27:00	71.5	93.4	30.09	12.08	0	22	0	4	
1:27:30	71.4	93.7	30.09	11.38					
1:28:00	71.3	93.8	30.10	7.56	0	18	1	4	
1:28:30	71.3	94.1	30.09	7.65					
1:29:00	71.3	94.3	30.09	1.65	0	7	1	4	
1:29:30	71.3	94.5	30.09	7.21					
1:30:00	71.3	94.8	30.09	2.43	1	10	1	4	NOTE: Boat hit floating piece of timber
1:30:30	71.3	94.9	30.09	0.87					...no apparent damage.
1:31:00	71.3	94.8	30.09	2.95	1	6	1	6	
1:31:30	71.2	94.9	30.09	4.43					
1:32:00	71.2	94.9	30.09	1.91	2	6	2	7	Engine speed @ 1600RPM
1:32:30	71.2	94.9	30.09	0.00					
1:33:01	71.2	95.0	30.09	4.61	2	6	2	7	Engine speed @ 2000RPM
1:33:30	71.2	95.1	30.09	2.61					
1:34:00	71.2	95.3	30.09	7.04	7	8	3	8	
1:34:30	71.2	95.2	30.09	9.63					
1:35:00	71.2	95.1	30.09	2.69	6	17	6	9	
1:35:30	71.1	95.1	30.09	6.60					
1:36:00	71.1	95.0	30.09	2.87	14	28	7	13	Engine speed @ 2400RPM
1:36:30	71.1	95.2	30.09	3.65					
1:37:00	71.1	95.2	30.09	9.99	15	27	16	24	Start Cruise Run into wind: 3000RPM @ 80deg
1:37:30	71.1	95.2	30.08	7.91					(Dorchester Bay)
1:38:00	71.0	95.2	30.09	9.47	12	45	14	32	Apparent wind avg 12.2 knots.
1:38:30	71.0	95.3	30.08	7.65					
1:39:00	71.0	95.4	30.08	5.13	11	54	14	32	Test runs in Dorchester Bay
1:39:30	71.0	95.4	30.09	7.56					(not offshore as in previous cruise runs)
1:40:00	71.1	95.4	30.08	5.30	9	31	12	38	
1:40:30	71.1	95.2	30.08	5.91					
1:41:00	71.1	95.0	30.08	12.25	12	35	10	38	
1:41:30	71.1	94.5	30.08	13.56					
1:42:00	71.1	94.5	30.08	14.86	6	53	13	37	
1:42:30	71.1	94.3	30.08	15.90					
1:43:00	71.0	94.2	30.08	16.16	6	52	6	27	
1:43:30	71.0	94.1	30.08	15.55					
1:44:00	71.0	94.2	30.08	17.03	2	29	7	19	
1:44:30	71.0	94.0	30.08	21.03					
1:45:00	70.9	93.9	30.08	19.47	2	9	3	14	Come around to 220deg
1:45:30	70.8	93.9	30.08	20.42					
1:46:00	70.8	93.8	30.09	12.51	1	25	3	9	
1:46:30	70.8	93.8	30.08	17.03					
1:47:00	70.7	93.7	30.08	16.25	0	20	1	9	
1:47:30	70.6	94.1	30.08	14.51					
1:48:00	70.4	94.8	30.08	14.25	3	45	1	9	Start Cruise away from wind: 3000RPM @ 220deg
1:48:30	70.4	95.3	30.08	13.64					
1:49:00	70.4	95.6	30.08	12.43	2	40	3	14	Apparent wind avg 15.2 knots (wind shift/lull?)
1:49:30	70.4	96.0	30.08	11.82					
1:50:00	70.2	96.3	30.08	19.20	2	45	2	18	
1:50:30	70.2	96.6	30.08	20.16					
1:51:00	70.2	96.7	30.08	18.86	2	31	2	20	
1:51:30	70.0	97.0	30.08	21.12					
1:52:00	70.0	97.1	30.08	20.51	0	23	2	23	
1:52:30	69.9	97.2	30.08	15.64					
1:53:00	69.9	97.4	30.08	13.03	1	14	1	24	

4:53:30	69.8	97.7	30.08	14.08						
4:54:00	69.8	97.7	30.08	7.65	3	39	1	23	←	Head for Yacht Club (Winthrop)
4:54:30	69.7	98.0	30.08	4.00					←	(Northeasterly then North)
4:55:00	69.7	98.2	30.08	4.00	9	29	4	23		
4:56:00	69.8	98.5	30.08	1.30						
4:56:30	69.8	98.5	30.08	3.65	6	9	10	24		
4:57:00	69.9	98.3	30.08	4.52						
4:57:30	69.9	98.2	30.08	6.60	7	13	6	24		Helmsmen smoking
4:58:00	69.9	98.1	30.08	5.82						
4:58:30	70.0	97.9	30.08	6.86	8	24	8	27		
4:59:00	70.0	97.7	30.08	7.65						
4:59:30	70.0	97.6	30.08	14.34	8	32	10	31		
5:00:00	70.0	97.6	30.08	12.95						
5:00:30	70.1	97.4	30.07	13.56	9	83	9	33		
5:01:00	70.2	97.1	30.08	7.21						
5:01:30	70.2	96.9	30.08	4.08	11	72	11	35		
5:02:00	70.2	96.7	30.08	18.25						
5:02:30	70.2	96.4	30.08	15.73	9	43	12	24		
5:03:00	70.2	96.2	30.08	16.16						
5:03:30	70.2	96.2	30.08	17.55	3	18	9	31		
5:04:00	70.2	96.1	30.07	18.07						
5:04:30	70.2	96.1	30.08	19.47	5	37	4	20		
5:05:00	70.2	95.9	30.08	20.33						
5:05:30	70.2	95.9	30.08	19.99	2	21	6	16		COI at transome
5:06:00	70.3	95.8	30.08	19.29						
5:06:30	70.4	95.7	30.08	21.03	23	7	2	11		
5:07:00	70.3	95.3	30.08	23.90						
5:07:30	70.4	95.2	30.08	24.07	36	50	1	8		change course to 300deg
5:08:00	70.4	95.3	30.08	21.55						
5:08:30	70.2	95.5	30.08	20.68	24	53	1	11		
5:09:00	70.2	95.5	30.08	19.03						
5:09:30	70.3	95.7	30.08	14.51	34	53	1	13		
5:10:00	70.2	95.7	30.08	16.95						
5:10:30	70.2	95.6	30.08	17.12	3	56	1	16		
5:11:00	70.2	95.7	30.08	16.77						
5:11:30	70.2	95.9	30.08	16.16	3	23	1	16		
5:12:00	70.2	95.9	30.08	17.12						
5:12:30	70.2	95.9	30.08	15.12	0	14	1	17		
5:13:00	70.2	95.8	30.08	13.64						
5:13:30	70.2	95.9	30.08	13.38	0	13	0	14		
5:14:00	70.3	95.8	30.08	13.12						
5:14:30	70.4	95.9	30.08	12.08	1	9	0	12		
5:15:00	70.4	95.9	30.08	9.82						
5:15:30	70.4	95.9	30.08	10.78	3	19	3	11		
5:16:00	70.4	95.7	30.08	7.73						
5:16:30	70.4	95.8	30.08	10.60	2	39	4	10		
5:17:00	70.5	95.8	30.08	11.91						
5:17:30	70.5	95.6	30.08	7.56	2	22	3	11		
5:18:00	70.6	95.7	30.08	5.82						
5:18:30	70.6	95.7	30.08	1.13	1	23	3	11		
5:19:00	70.7	95.7	30.09	0.00						
5:19:31	70.7	95.7	30.08	6.26	10	11	2	11		
5:20:00	70.8	95.5	30.08	0.96						
5:20:30	70.8	95.1	30.08	1.04	11	8	14	10		Arrive Pleasant Point Yacht Club
5:21:00	70.8	95.0	30.08	0.00						
5:21:31	70.9	94.4	30.08	1.74	8	3	8	10		
5:22:00	70.9	94.3	30.08	2.69						
5:22:30	70.9	93.8	30.08	3.13	8	1	7	10		
5:23:00	70.9	93.8	30.08	1.65						
5:23:30	71.0	93.7	30.08	1.39	8	9	1	10		

24:00	71.0	93.6	30.08	1.48				
24:30	71.0	93.7	30.08	0.00	7	3	3	10
25:01	71.0	93.7	30.08	1.39				
25:30	71.1	93.7	30.08	1.48	6	1	0	9
26:00	71.1	93.4	30.08	2.52	6	2	1	9
27:00	.	.	.	.	6	0	1	9
28:00	.	.	.	.	6	0	1	9
29:00	.	.	.	.	6	0	2	9
30:00	.	.	.	.	6	0	6	10
31:00	.	.	.	.	6	6	4	11
32:00	.	.	.	.	7	9	7	8
33:00	.	.	.	.	7	9	8	9
34:00	.	.	.	.	9	11	9	10
35:00	.	.	.	.	9	11	10	12
36:00	.	.	.	.	10	12	11	12
37:00	.	.	.	.	12	14	11	13
38:00	.	.	.	.	12	14	13	14
39:00	.	.	.	.	12	16	13	16
40:00	.	.	.	.	14	17	14	16
41:00	.	.	.	.	14	16	14	16
42:00	.	.	.	.	12	16	14	16
43:00	.	.	.	.	12	16	13	14
44:00	.	.	.	.	9	14	14	14
45:00	.	.	.	.	9	13	12	13
46:00	.	.	.	.	9	12	10	11
47:00	.	.	.	.	9	11	8	10
48:00	.	.	.	.	8	10	7	10
49:00	.	.	.	.	7	9	7	9
50:00	.	.	.	.	7	8	6	8
51:00	.	.	.	.	7	8	6	8
52:00	.	.	.	.	8	7	6	7
53:00	.	.	.	.	2	7	4	6
54:00	.	.	.	.	0	6	4	6
55:00	.	.	.	.	0	6	4	4
56:00	.	.	.	.	0	6	3	4
57:00	.	.	.	.	0	4	3	4
58:00	.	.	.	.	-1	4	3	4
59:00	.	.	.	.	-1	4	2	4
60:00	.	.	.	.	-1	4	2	4

Idling at dock

Engines off (approx)

APPENDIX B

Chesapeake Bay Boat Test Data

Coast Guard Boat Tests - Chesapeake Bay - Monday, December 10, 1990

Time of Day	Temp F	Rel Hum %	Baro Press in Hg	Head Wind knots	CO1 ppm	CO2 ppm	CO3 ppm	CO4 ppm	Remarks
09:18:32	52.00	40.90	30.15	1.80	-001	-000	-000	000	285 deg (W-W)
09:18:59	52.10	41.90	30.14	1.57					
09:19:31	51.90	42.10	30.14	1.82	-001	-000	-000	000	
09:20:01	51.70	40.80	30.14	1.87					NOTES: Sensor CO1 in cabin at forepeak of boat
09:20:31	51.70	41.30	30.14	3.99	-001	-000	-000	000	CO2 in cabin at helmsman station
09:21:01	51.70	42.50	30.14	2.82					CO3 at center of transome
09:21:31	51.70	41.80	30.14	1.61	-001	-000	-000	000	CO4 in engine space
09:22:01	51.60	41.50	30.14	4.57					
09:22:31	51.70	42.00	30.14	2.46	-001	-000	-000	000	Weather clear with a cold front
09:23:03	51.70	42.30	30.14	1.03					moving thru at approx 10:30 bringing
09:23:31	51.90	41.00	30.14	5.02	-001	-000	-000	000	10 to 20 knot W-W-W breezes
09:24:01	51.80	40.40	30.14	1.09					(wind initially 3-8 knots SW)
09:24:31	51.80	40.80	30.14	2.46	-001	-000	-000	000	Avg Temp: 59 deg F (51.7-65.9)
09:25:01	51.80	41.30	30.14	1.61					Avg RH: 38% (22.8-59.7)
09:25:31	51.70	41.40	30.14	5.07	-001	-000	-000	000	Avg Press: 30.10 in Hg (30.05-30.15)
09:26:01	51.70	40.60	30.14	1.42					
09:26:31	51.80	41.90	30.14	2.74	-001	-000	-000	000	Test Boat: 36' Silverton Sedan Cruiser
09:27:01	51.80	42.70	30.14	1.53					"Forever Evelyn" MD 1840AL
09:27:31	51.90	42.60	30.14	3.70	-001	-000	-000	000	operator: Cordell Hart
09:28:01	51.90	42.90	30.14	2.79					
09:28:31	52.00	41.60	30.14	1.96	-001	-000	-000	-000	
09:29:01	52.00	41.70	30.14	2.05					Boat equipped with twin 302-CID GM engines;
09:29:33	52.00	42.40	30.14	2.02	-001	-000	-000	000	Exhaust exits are on the port and starbord
09:30:00	52.20	41.70	30.14	1.76					side of the boat approx 10 feet from the
09:30:31	52.00	41.80	30.14	2.13	-01	-000	-000	000	stern, approx 11 feet apart, and located at
09:31:01	52.00	42.00	30.14	1.76					the waterline.
09:31:31	51.90	42.80	30.14	1.76	-001	-000	-000	000	
09:32:01	51.90	41.60	30.14	2.66					
09:32:31	51.90	41.90	30.14	1.76	-001	-000	-000	000	
09:33:01	51.90	42.40	30.14	1.26					
09:33:31	52.00	42.80	30.14	3.49	-001	-000	-000	000	
09:34:02	52.00	42.50	30.14	2.77					
09:34:31	52.00	42.50	30.14	4.49	-001	-000	-000	-000	
09:35:01	52.10	42.10	30.14	1.59					
09:35:31	52.20	41.80	30.14	2.59	-001	-000	015	-000	
09:36:05	52.40	42.50	30.14	3.03					285 deg (W-W) Start Engines
09:36:31	52.70	42.30	30.15	.	-001	000	086	-000	
09:37:01	52.70	40.30	30.14	1.40					
09:37:32	52.80	39.50	30.14	2.59	-001	007	077	000	
09:37:59	53.00	39.60	30.14	2.60					
09:38:32	53.00	39.60	30.14	2.38	-001	009	035	001	
09:39:01	53.20	39.30	30.14	1.77					
09:39:31	53.30	39.70	30.14	1.53	000	004	024	002	
09:40:01	53.40	38.60	30.14	1.98					
09:40:31	53.60	37.80	30.14	1.28	000	004	021	003	
09:41:03	53.70	39.20	30.14	1.68					
09:41:31	53.90	39.20	30.14	.	001	007	119	003	
09:42:01	54.10	39.50	30.14	1.68					
09:42:31	54.10	37.50	30.14	.	002	006	053	004	
09:43:00	54.30	37.70	30.14	1.39					
09:43:31	54.40	36.40	30.14	1.05	002	012	160	006	
09:44:03	54.50	36.60	30.14	1.22					

09:44:32	54.98	36.40	30.14	.	002	023	107	013	
09:45:00	55.18	35.30	30.14	5.51					
09:45:31	55.00	36.00	30.14	1.91	004	072	144	019	
09:46:01	55.00	36.20	30.14	6.09					265 deg (WNW) Pull off of dock
09:46:32	54.98	36.30	30.14	7.86	008	072	067	023	
09:47:01	54.80	38.30	30.14	10.76					
09:47:31	54.70	38.30	30.14	9.89	025	054	046	024	
09:48:01	54.70	37.80	30.14	0.81					
09:48:32	54.90	37.10	30.14	1.12	035	031	104	011	
09:49:00	55.50	36.90	30.14	.					
09:49:30	56.40	35.10	30.14	0.80	036	037	092	012	
09:50:03	56.60	34.60	30.14	.					
09:50:31	56.90	35.10	30.14	.	034	044	077	013	
09:51:01	57.00	35.90	30.14	.					
09:51:30	57.00	34.90	30.14	.	033	046	024	009	
09:52:00	57.20	34.30	30.14	.					
09:52:30	57.40	35.30	30.14	.	034	043	037	009	
09:53:00	57.90	35.60	30.14	.					
09:53:31	58.40	34.90	30.14	.	033	037	043	007	
09:54:07	59.10	33.10	30.13	1.40					
09:54:33	59.50	30.20	30.13	.	032	036	020	008	
09:55:02	60.70	28.90	30.14	.					
09:55:30	61.30	28.80	30.13	6.33	031	031	005	009	
09:56:01	62.20	26.70	30.13	1.02					
09:56:34	63.50	23.70	30.13	.	027	018	004	007	
09:57:01	64.70	23.10	30.13	.					
09:57:30	65.70	23.20	30.13	0.92	020	017	008	006	90 deg (E) - in channel, speed 2800 RPM
09:57:59	66.20	21.70	30.13	3.18					
09:58:33	65.90	22.80	30.13	4.49	017	014	009	009	
09:59:01	65.90	24.60	30.13	5.56					
09:59:31	65.70	25.00	30.13	6.33	016	017	007	008	
10:00:01	65.60	25.80	30.13	4.77					
10:00:31	65.60	26.20	30.12	4.35	015	011	008	006	
10:01:01	65.50	26.30	30.12	5.81					
10:01:32	65.50	26.90	30.12	3.28	013	011	004	005	
10:02:01	65.40	28.10	30.12	3.98					
10:02:32	65.40	28.80	30.12	4.44	011	011	001	004	
10:03:01	65.40	28.80	30.12	5.58					
10:03:31	65.20	29.30	30.12	4.58	010	008	002	003	
10:04:01	65.00	29.90	30.12	6.20					
10:04:31	64.90	30.70	30.12	4.99	008	008	000	002	
10:05:01	64.70	30.90	30.12	4.45					
10:05:31	64.60	32.20	30.12	1.41	007	004	007	002	
10:06:01	64.70	31.60	30.11	1.41					
10:06:33	64.80	31.10	30.12	.	005	004	028	003	
10:07:02	65.00	30.90	30.11	.					
10:07:30	65.30	30.00	30.11	2.71	004	006	027	009	
<hr/>									
10:08:01	65.10	30.50	30.11	9.30					120 deg (SE) - Start run across bay - E-1
10:08:32	64.90	31.60	30.11	12.13	003	013	011	008	
10:09:01	64.80	32.80	30.11	9.29					
10:09:31	64.60	31.80	30.11	8.05	003	007	011	004	
10:10:01	64.40	31.80	30.11	6.53					
10:10:31	64.20	33.10	30.11	9.19	004	005	008	004	
10:11:02	64.00	33.40	30.11	10.61					
10:11:31	63.90	33.80	30.11	11.01	004	005	014	003	
10:12:02	63.70	33.90	30.11	11.83					
10:12:32	63.60	33.70	30.11	11.17	004	005	011	003	
10:13:01	63.50	33.60	30.11	9.94					
10:13:31	63.40	32.60	30.11	11.94	004	005	018	004	

10:14:02	63.30	32.70	30.11	12.39				
10:14:32	63.30	34.00	30.11	8.85	003	010	007	004
10:15:01	63.20	33.40	30.11	12.48				
10:15:32	63.10	33.50	30.12	12.03	003	005	012	004
10:16:02	63.10	34.90	30.11	12.41				
10:16:32	63.00	34.30	30.11	9.23	003	004	011	004
10:17:02	62.80	34.80	30.11	10.40				
10:17:31	62.70	32.90	30.11	12.52	003	006	015	004
10:18:01	62.60	35.80	30.11	16.20				
10:18:31	62.50	39.70	30.11	18.05	003	005	032	005
10:19:02	62.30	40.60	30.11	14.89				
10:19:32	62.10	40.40	30.11	16.73	003	007	049	007
10:20:01	61.90	42.10	30.11	18.73				
10:20:31	61.60	42.30	30.11	17.45	002	012	074	010
10:21:01	61.60	42.20	30.11	18.36				
10:21:32	61.50	39.80	30.11	18.53	003	020	047	014
10:22:01	61.40	41.10	30.11	16.45				
10:22:31	61.30	40.00	30.11	18.75	004	022	060	015
10:23:02	61.30	42.00	30.11	18.87				
10:23:31	61.30	42.50	30.11	19.07	005	026	062	015
10:24:01	61.20	41.90	30.11	19.68				
10:24:31	61.10	43.00	30.11	17.93	006	026	046	016
10:25:01	60.90	43.20	30.11	18.29				
10:25:31	60.90	43.50	30.11	19.22	006	027	043	014
10:26:01	60.70	43.10	30.11	20.34				
10:26:31	60.70	43.90	30.11	20.95	007	023	034	013
10:27:01	60.50	43.00	30.11	18.26				
10:27:31	60.40	43.60	30.11	18.90	009	023	022	012
10:28:01	60.00	44.40	30.11	18.25				
10:28:31	59.70	45.70	30.11	19.02	009	017	032	010
10:29:01	59.40	46.40	30.11	18.74				
10:29:31	59.40	45.70	30.11	20.06	010	014	042	010
10:30:02	59.40	45.70	30.12	17.39				

End Easterly Run #1

10:30:31	59.30	46.10	30.12	18.41	011	016	064	012
10:31:02	59.20	46.30	30.12	17.94				
10:31:31	59.10	46.70	30.12	18.87	011	021	065	015

10:32:02	59.00	46.20	30.12	19.15				
10:32:31	59.00	46.40	30.11	22.07	011	023	052	019
10:33:01	58.80	45.90	30.11	21.77				
10:33:31	58.30	48.10	30.12	21.10	012	027	101	025
10:34:01	57.70	51.40	30.12	13.34				
10:34:32	57.20	52.90	30.12	11.80	012	042	128	033
10:35:01	57.00	52.60	30.11	12.33				
10:35:32	57.10	50.50	30.11	12.61	012	054	168	036
10:36:01	57.00	50.50	30.11	11.62				
10:36:32	57.20	50.30	30.11	13.57	013	064	135	044
10:37:01	57.10	49.50	30.11	10.97				
10:37:31	57.00	49.90	30.11	12.15	017	067	142	040
10:38:02	56.90	51.10	30.11	10.85				
10:38:31	56.80	51.20	30.11	11.96	021	066	152	041
10:39:01	56.70	51.70	30.11	13.09				
10:39:31	56.70	50.40	30.11	7.93	029	071	155	043
10:40:02	57.00	46.00	30.10	16.08				
10:40:31	57.30	45.80	30.11	12.09	031	087	211	047
10:41:02	57.20	44.30	30.11	11.29				
10:41:31	57.20	44.70	30.11	8.43	036	095	173	050
10:42:02	57.20	46.10	30.11	10.37				
10:42:31	57.40	44.50	30.11	12.08	044	089	232	054

325 deg (NW) - Start return run - W-1

Wind shift W - NW (front coming in?)

330 deg (NW)

10:43:02	57.70	43.10	30.11	11.54				
10:43:31	57.80	41.10	30.10	14.10	055	110	388	047
10:44:02	57.80	40.00	30.10	2.94				
10:44:32	57.90	37.20	30.10	12.94	064	157	331	066
10:45:01	58.10	40.20	30.10	21.82				
10:45:32	58.10	40.90	30.10	20.58	078	177	247	102
10:46:01	57.90	42.90	30.10	22.81				
10:46:31	58.00	39.80	30.10	20.16	095	154	272	098
10:47:01	58.00	41.00	30.10	22.26				
10:47:31	58.10	41.00	30.10	23.25	113	156	216	098
10:48:01	58.20	39.40	30.10	21.32				
10:48:31	58.20	42.40	30.10	23.88	122	142	254	101
10:49:01	58.00	42.70	30.10	19.46				
10:49:31	57.90	40.70	30.10	13.69	125	142	348	082
10:50:01	58.20	40.90	30.10	12.83				
10:50:31	58.40	42.80	30.10	15.42	122	182	266	096
10:51:01	58.60	41.70	30.10	17.62				
10:51:31	58.70	41.70	30.10	15.00	122	175	335	084
10:52:01	58.70	38.90	30.10	12.26				
10:52:31	58.70	42.50	30.10	15.34	128	190	285	097
10:53:01	58.80	43.40	30.10	14.94				
10:53:31	58.90	42.00	30.10	10.89	134	170	299	080
10:54:01	59.10	40.60	30.10	8.66				
10:54:31	59.30	38.90	30.09	7.35	137	165	336	073
10:55:01	59.40	38.90	30.09	10.27				
10:55:31	59.60	37.90	30.10	13.50	140	183	289	084
10:56:01	59.70	39.80	30.10	3.97				
10:56:31	59.80	38.90	30.10	10.90	140	183	384	081
10:57:01	59.80	38.70	30.10	7.68				
10:57:31	60.00	37.80	30.10	3.78	144	204	407	079
10:58:01	60.20	37.10	30.10	7.15				
10:58:31	60.50	36.60	30.10	2.15	148	240	394	093
10:59:01	60.60	35.20	30.10	13.16				
10:59:31	60.70	37.20	30.09	14.89	151	255	273	121
11:00:01	60.70	35.10	30.10	19.51				
11:00:31	60.70	36.70	30.09	19.23	161	218	300	116
11:01:01	60.60	35.50	30.08	27.91				
11:01:31	60.60	34.40	30.09	24.72	178	189	280	133
11:02:01	60.40	36.80	30.08	29.32				
11:02:31	60.40	36.30	30.08	24.99	176	183	336	118
11:03:01	60.20	35.10	30.09	20.02				
11:03:31	60.10	38.10	30.08	22.74	166	183	292	091
11:04:01	60.10	35.40	30.09	11.01				
11:04:31	60.20	35.10	30.09	21.19	164	177	254	107
11:05:01	60.50	36.20	30.09	21.09				
11:05:31	60.50	34.30	30.08	28.74	158	154	217	124
11:06:01	60.30	36.70	30.08	30.25				
11:06:31	60.00	37.80	30.09	20.14	152	152	202	119
11:07:01	60.00	36.50	30.08	27.61				
11:07:31	60.00	35.30	30.08	26.66	152	144	184	111
11:08:01	59.90	35.40	30.09	29.21				
11:08:31	59.80	36.20	30.09	28.02	147	126	239	101
11:09:01	59.60	36.00	30.08	24.93				
11:09:31	59.40	37.30	30.08	27.56	138	135	255	104
11:10:01	59.40	36.00	30.08	27.08				
11:10:31	59.40	34.80	30.09	20.18	132	147	328	104
11:11:01	59.50	35.30	30.09	16.94				
11:11:31	59.60	35.30	30.09	23.22	126	177	239	102
11:12:01	59.60	34.30	30.09	25.31				
11:12:31	59.60	34.00	30.08	24.89	125	163	260	111

320 deg (NW)

enter South River from Bay

11:13:01	59.60	34.40	30.09	20.98					
11:13:31	59.70	36.10	30.09	21.77	132	154	198	103	
11:14:01	59.70	35.50	30.09	21.63					330 deg (NRW)
11:14:31	59.80	35.40	30.09	22.33	134	139	243	105	
11:15:01	59.70	37.00	30.09	25.36					
11:15:31	59.60	35.20	30.09	23.02	133	137	247	107	
11:16:01	59.70	35.10	30.09	26.41					
11:16:31	59.60	36.00	30.08	27.98	130	155	291	117	
11:17:01	59.50	35.80	30.08	24.41					
11:17:31	59.50	36.70	30.08	29.49	126	158	219	113	
11:18:01	59.50	36.80	30.08	26.80					
11:18:31	59.40	37.60	30.08	28.72	126	150	128	116	
11:19:01	59.40	36.70	30.08	30.41					325 deg (NR)
11:19:31	59.30	36.80	30.08	30.87	128	121	182	099	
11:20:01	59.20	37.80	30.08	31.67					End Westery Run #1
<hr/>									
11:20:31	59.10	37.40	30.07	33.22	127	123	163	099	
11:21:01	59.00	36.80	30.08	34.80					
11:21:31	59.00	37.40	30.08	39.28	122	121	050	088	
11:22:01	58.90	37.10	30.08	28.08					310 deg (NR) (into wind), throttle down for
11:22:31	58.80	38.10	30.08	34.39	118	069	020	062	Rt. 2 bridge
11:23:01	58.70	37.20	30.08	30.71					
11:23:31	58.70	36.60	30.09	28.49	115	046	019	046	
11:24:01	58.70	36.40	30.09	25.64					
11:24:31	58.70	37.90	30.09	21.44	111	030	018	035	
11:25:01	58.70	37.70	30.09	23.08					
11:25:31	58.70	36.50	30.09	31.86	104	031	021	029	
11:26:01	58.70	36.00	30.09	30.90					
11:26:31	58.50	37.50	30.09	23.49	094	025	031	020	
11:27:01	58.40	37.50	30.08	26.32					
11:27:31	58.30	36.00	30.08	34.67	086	024	081	028	
11:28:01	58.40	37.30	30.08	32.59					resume speed
11:28:31	58.40	37.70	30.08	33.55	073	034	104	035	
11:29:01	58.40	36.10	30.08	26.55					
11:29:31	58.50	37.00	30.09	25.70	057	045	075	044	
11:30:01	58.50	37.40	30.10	25.40					Head toward dock for lunch - maneuvering
11:30:31	58.50	35.20	30.10	22.07	047	049	057	036	
11:31:01	58.50	36.10	30.10	7.58					
11:31:31	58.50	36.60	30.10	6.19	045	041	017	032	
11:32:01	58.50	35.70	30.10	16.84					
11:32:31	58.40	37.00	30.10	4.23	028	031	044	025	
11:33:03	58.50	37.30	30.10	5.05					
11:33:30	58.60	36.80	30.10	15.41	030	023	055	020	
11:34:01	58.50	35.20	30.10	14.74					
11:34:31	58.60	35.30	30.10	13.96	030	026	102	021	
11:35:01	58.70	35.60	30.10	14.56					310 deg (NR) - Tie up at dock
11:35:31	58.90	35.00	30.10	8.27	030	033	074	022	
11:36:01	59.00	34.90	30.10	5.97					
11:36:31	59.00	35.00	30.10	9.76	030	038	006	025	Engine off
11:37:01	59.20	34.60	30.09	12.49					
11:37:31	59.30	33.60	30.10	13.30	028	022	006	025	
11:38:01	59.40	33.40	30.10	12.47					
11:38:31	59.60	33.10	30.10	6.04	028	019	005	021	
11:39:01	59.70	33.80	30.10	12.05					
11:39:31	59.90	33.10	30.10	11.37	028	015	005	019	
11:40:01	60.00	32.20	30.10	8.36					
11:40:31	60.10	32.50	30.10	7.27	030	022	005	019	
11:41:01	60.30	33.10	30.10	2.72					
11:41:31	60.50	33.40	30.10	4.95	027	024	005	018	
11:42:01	60.60	33.80	30.11	8.29					

11:42:31	60.70	32.10	30.10	10.07	025	024	005	018
11:43:01	60.80	32.90	30.10	5.56				
11:43:31	60.80	31.80	30.10	7.81	022	024	005	017
11:44:01	60.90	32.10	30.10	8.66				
11:44:31	60.90	32.00	30.10	12.62	020	024	005	017
11:45:01	61.00	31.50	30.10	10.66				
11:45:31	61.10	31.80	30.10	9.77	019	024	005	017
11:46:01	61.10	33.30	30.10	10.06				
11:46:31	61.20	32.70	30.10	12.21	018	023	005	017
11:47:01	61.30	32.10	30.10	10.08				
11:47:31	61.30	32.80	30.10	10.26	017	022	005	016
11:48:01	61.30	31.90	30.10	17.79				
11:48:31	61.30	32.30	30.10	8.37	017	022	005	016
11:49:01	61.30	32.80	30.10	7.13				
11:49:31	61.30	32.30	30.10	12.70	017	021	004	015
11:50:01	61.30	32.50	30.10	3.71				
11:50:31	61.30	32.80	30.10	18.28	017	021	004	015
11:51:01	61.20	32.10	30.10	11.32				
11:51:31	61.30	31.70	30.10	12.57	017	021	004	014
11:52:01	61.30	31.80	30.10	8.97				
11:52:31	61.30	33.50	30.10	7.02	017	020	004	014
11:53:01	61.30	32.50	30.10	12.48				
11:53:31	61.30	31.90	30.10	12.24	017	020	004	014
11:54:01	61.30	31.80	30.10	10.17				
11:54:30	61.20	32.70	30.10	8.74	017	020	004	014
11:55:01	61.20	32.70	30.10	8.31				
11:55:31	61.20	33.50	30.10	8.94	017	020	005	014
11:56:01	61.20	33.20	30.10	11.05				
11:56:31	61.20	33.80	30.10	7.82	017	020	004	015
11:57:01	61.20	32.90	30.10	7.96				
11:57:31	61.20	32.00	30.10	12.64	016	019	004	015
11:58:01	61.20	31.70	30.11	9.79				
11:58:31	61.30	32.40	30.10	7.49	016	019	004	015
11:59:01	61.30	32.00	30.10	7.54				
11:59:31	61.30	31.90	30.10	2.56	016	019	004	016
12:00:02	61.30	31.90	30.11	3.66				
12:00:31	61.40	32.70	30.10	5.22	016	019	004	016
12:01:01	61.50	32.20	30.10	5.89				
12:01:31	61.40	31.50	30.09	13.48	016	019	004	016
12:02:01	61.30	32.20	30.10	8.38				
12:02:31	61.20	32.80	30.10	8.58	015	018	004	015
12:03:01	61.10	33.00	30.10	6.16				
12:03:31	61.20	33.10	30.10	3.65	015	019	004	015
12:04:01	61.10	33.80	30.11	5.56				
12:04:31	61.10	34.40	30.11	7.98	015	019	004	016
12:05:01	61.10	33.90	30.10	8.66				
12:05:31	61.10	34.80	30.11	10.57	015	018	004	016
12:06:01	61.10	34.00	30.10	7.56				
12:06:31	61.10	33.40	30.10	6.29	015	018	004	016
12:07:01	61.10	33.60	30.11	8.31				
12:07:31	61.10	33.20	30.11	7.86	015	018	003	017
12:08:01	61.00	33.60	30.11	7.88				
12:08:31	61.00	33.80	30.11	11.67	015	018	004	017
12:09:01	61.00	33.60	30.11	10.62				
12:09:31	61.10	34.90	30.11	8.10	015	017	003	017
12:10:01	61.00	33.80	30.11	7.25				
12:10:31	61.00	34.30	30.11	8.53	015	017	003	016
12:11:01	61.00	34.90	30.11	11.87				
12:11:31	61.00	35.70	30.10	17.59	015	017	003	016
12:12:01	61.00	33.40	30.11	16.52				

12:12:31	61.00	33.80	30.11	13.84	014	014	003	014
12:13:01	60.90	34.40	30.11	12.83				
12:13:31	60.90	34.10	30.10	19.57	014	015	003	013
12:14:01	60.90	33.10	30.10	14.93				
12:14:31	60.90	35.00	30.10	19.12	014	014	003	012
12:15:01	60.90	33.60	30.10	22.20				
12:15:31	60.90	33.50	30.10	16.05	014	012	003	010
12:16:01	60.90	34.00	30.10	14.69				
12:16:31	60.90	34.50	30.10	16.13	014	012	003	009
12:17:01	60.90	34.80	30.10	16.01				
12:17:31	60.90	34.60	30.10	15.91	014	011	003	009
12:18:01	60.90	33.20	30.10	17.45				
12:18:31	60.90	34.50	30.10	19.15	014	011	003	009
12:19:01	60.90	35.50	30.10	15.84				
12:19:31	60.90	34.90	30.10	11.01	014	010	003	008
12:20:01	60.80	33.30	30.10	15.70				
12:20:31	60.80	33.70	30.10	11.13	014	010	003	008
12:21:01	60.90	33.70	30.10	9.57				
12:21:31	6.00	33.70	30.10	14.84	014	012	003	008
12:22:01	1.00	34.10	30.10	13.05				
12:22:31	61.00	33.50	30.10	14.23	013	011	003	009
12:23:01	61.10	34.40	30.10	14.55				
12:23:31	61.30	31.90	30.10	11.28	013	011	003	008
12:24:01	61.40	32.90	30.10	13.06				
12:24:31	61.50	32.50	30.10	6.31	013	012	003	008
12:25:01	61.50	31.80	30.10	12.42				
12:25:31	61.50	32.10	30.10	10.62	013	012	003	009
12:26:01	61.70	32.60	30.10	12.98				
12:26:31	61.80	33.50	30.10	12.93	012	012	003	009
12:27:01	61.80	32.50	30.10	7.52				
12:27:31	61.80	33.90	30.10	10.75	012	014	003	009
12:28:01	61.80	31.90	30.10	10.14				
12:28:31	61.90	32.00	30.10	8.13	012	014	003	009
12:29:01	61.90	32.30	30.10	6.75				
12:29:31	61.90	32.10	30.10	9.86	012	014	003	010
12:30:01	61.90	31.30	30.10	10.94				
12:30:31	61.90	32.40	30.10	13.66	012	014	003	010
12:31:01	61.90	32.10	30.10	11.37				
12:31:31	61.90	31.50	30.10	8.31	011	013	003	010
12:32:02	61.90	33.30	30.10	10.79				
12:32:31	61.90	32.90	30.10	5.72	011	013	003	010
12:33:01	61.90	34.20	30.10	5.01				
12:33:31	61.90	34.20	30.10	5.28	011	014	003	010
12:34:02	61.90	33.90	30.10	3.03				
12:34:31	61.90	33.30	30.10	5.01	011	014	003	011
12:35:01	62.00	33.90	30.10	8.18				
12:35:31	62.00	32.80	30.10	6.37	011	013	003	011
12:36:01	62.00	33.60	30.10	1.13				
12:36:31	62.00	32.40	30.10	7.69	011	013	003	012
12:37:02	62.00	33.20	30.10	8.71				
12:37:32	62.00	33.20	30.10	12.92	011	010	003	012
12:38:01	61.90	32.00	30.10	9.01				
12:38:32	62.00	32.00	30.10	7.01	011	007	003	011
12:39:02	62.00	33.80	30.10	8.39				
12:39:32	61.90	33.80	30.10	9.84	010	005	003	012
12:40:02	61.90	34.00	30.09	11.73				
12:40:32	61.90	32.80	30.10	10.44	009	005	005	011
12:41:02	61.80	34.60	30.09	12.73				
12:41:31	61.60	33.80	30.10	12.25	008	003	116	010
12:42:02	61.60	34.00	30.10	9.58				

310 deg (NW) - Restart engines

2:42:31	61.50	33.50	30.10	8.15	008	010	117	012
2:43:01	61.50	33.80	30.09	9.10				
2:43:32	61.50	33.10	30.09	3.79	007	026	122	015
2:44:02	61.50	33.80	30.09	1.05				
2:44:33	61.70	33.70	30.10	1.46	007	036	027	019
2:45:01	62.10	34.40	30.10	3.58				
2:45:31	62.00	31.20	30.09	3.11	007	031	016	020
2:46:01	62.00	31.10	30.09	4.60				
2:46:32	62.10	30.80	30.09	1.42	008	021	019	020
2:47:03	62.10	33.50	30.09	1.43				
2:47:31	62.30	32.20	30.09	1.17	012	016	016	009
2:48:01	62.10	32.90	30.09	0.89				
2:48:32	62.00	32.30	30.09	7.24	018	017	026	018
2:49:02	62.10	31.60	30.09	6.12				
2:49:31	62.20	32.90	30.09	5.61	018	014	022	023
2:50:02	62.30	30.60	30.10					
2:50:30	62.30	31.60	30.09	10.03	017	011	025	023
2:51:01	61.90	32.90	30.09	3.63				
2:51:31	61.90	33.40	30.09	3.91	016	009	039	024
2:52:01	61.90	33.00	30.09	1.46				
2:52:32	61.90	33.00	30.09	10.21	015	014	009	027
2:53:01	62.10	31.70	30.09	6.36				
2:53:31	62.10	33.30	30.09	5.81	015	012	005	020
2:54:02	62.10	33.10	30.09	8.35				
2:54:31	62.10	33.10	30.09		014	008	008	011

120 deg (SE) - trailing wind

12:55:00	62.30	34.20	30.09	4.60				
12:55:31	62.20	34.70	30.09	4.21	011	006	003	006
12:56:01	62.20	35.20	30.09	5.44				
12:56:32	62.20	35.00	30.09	2.01	009	004	004	005
12:57:01	62.10	33.60	30.09	5.90				
12:57:32	62.10	35.70	30.09	2.83	008	003	004	004
12:58:01	61.90	36.00	30.09					
12:58:31	61.90	35.60	30.09	2.01	007	003	009	005
12:59:04	61.70	35.30	30.09	1.56				
12:59:31	61.90	36.00	30.09	1.08	006	003	004	005
13:00:01	61.80	36.40	30.09	3.37				
13:00:31	61.70	37.80	30.09	2.11	005	002	003	004
13:01:01	61.70	37.30	30.09	1.69				
13:01:31	61.60	36.50	30.08	2.34	004	002	003	003
13:02:01	61.60	37.30	30.09	4.08				
13:02:32	61.60	37.80	30.08	7.59	004	001	005	003
13:03:02	61.60	37.50	30.08	1.97				
13:03:31	61.60	36.60	30.09	3.93	003	002	003	003
13:04:01	61.60	36.90	30.08	5.68				
13:04:32	61.50	36.30	30.08	7.63	003	001	004	003
13:05:01	61.30	39.00	30.08	8.82				
13:05:32	60.90	38.90	30.08	8.92	003	001	004	004
13:06:01	60.70	38.40	30.08	6.34				
13:06:32	60.50	36.90	30.08	7.31	002	001	004	004
13:07:01	60.30	38.20	30.08	9.15				
13:07:31	60.10	37.00	30.08	9.70	002	001	004	004
13:08:01	60.00	41.40	30.08	9.13				
13:08:32	59.60	42.20	30.08	8.33	002	001	005	004
13:09:02	59.30	45.10	30.08	10.45				
13:09:32	59.00	45.50	30.08	10.15	002	002	009	005
13:10:01	58.60	47.60	30.08	9.81				
13:10:32	58.10	47.20	30.07	10.57	002	003	015	007
13:11:02	57.90	47.20	30.08	9.35				
13:11:31	57.60	46.90	30.08	9.31	001	006	005	007

140 deg (SE) - Speed to 2800 RPM - Start Run E2

Out of So. River into Bay

140 deg (SE) - Trailing wind; Bilge blower turned off

140 deg (SE)

13:41:01	55.30	57.30	30.07	21.01
13:41:31	55.20	57.50	30.07	19.97
13:42:01	55.10	58.00	30.08	21.34
13:42:31	54.90	59.70	30.07	19.84
13:43:01	54.70	58.50	30.07	19.41
13:43:31	54.50	57.20	30.07	23.19
13:44:01	54.50	55.60	30.07	24.69
13:44:31	54.50	55.20	30.07	24.23
13:45:01	54.50	53.10	30.06	29.23
13:45:31	54.60	51.00	30.07	28.79
13:46:01	54.70	52.20	30.07	31.19
13:46:31	54.60	54.00	30.07	24.44
13:47:01	54.60	54.70	30.07	24.26
13:47:31	54.50	54.80	30.07	23.93
13:48:01	54.50	53.30	30.07	27.66
13:48:31	54.50	51.80	30.07	29.33
13:49:01	54.50	52.40	30.06	33.61
13:49:31	54.70	49.20	30.06	32.74
13:50:01	54.70	46.70	30.06	32.65
13:50:31	54.80	50.30	30.07	27.69
13:51:01	54.80	46.70	30.06	28.62
13:51:31	54.90	48.30	30.06	35.17
13:52:01	55.00	46.20	30.06	34.53
13:52:31	55.10	48.40	30.07	28.69
13:53:01	55.10	52.30	30.07	22.75
13:53:31	55.10	51.70	30.07	22.16
13:54:01	55.10	49.40	30.07	21.50
13:54:31	55.30	48.50	30.07	25.18
13:55:01	55.30	50.70	30.08	22.61
13:55:31	55.30	51.10	30.08	19.08
13:56:01	55.30	49.80	30.07	20.89
13:56:31	55.40	47.70	30.07	22.83
13:57:01	55.50	49.00	30.08	20.37
13:57:31	55.50	48.30	30.08	21.95
13:58:01	55.60	49.10	30.07	22.77
13:58:31	55.70	48.80	30.07	19.80
13:59:01	55.80	48.30	30.07	27.19
13:59:31	55.90	44.30	30.07	24.15
14:00:01	56.10	45.60	30.07	21.07
14:00:31	56.20	45.10	30.07	19.02
14:01:01	56.70	44.40	30.07	21.04
14:01:31	57.20	42.40	30.07	18.71
14:02:01	57.80	40.90	30.06	15.56
14:02:31	58.20	42.30	30.06	20.14
14:03:01	58.60	41.40	30.07	27.75
14:03:31	58.80	43.30	30.07	29.73
14:04:01	58.80	43.60	30.06	30.86
14:04:31	58.70	43.70	30.05	25.98
14:05:01	58.70	38.50	30.06	29.36
14:05:31	58.70	39.60	30.06	32.91
14:06:01	58.70	42.40	30.06	33.20
14:06:31	58.60	40.50	30.06	30.27
14:07:01	58.70	39.60	30.06	32.00
14:07:31	58.70	42.50	30.07	28.98
14:08:01	58.60	42.30	30.07	30.38
14:08:31	58.50	41.50	30.07	28.63
14:09:01	58.50	43.10	30.07	28.79
14:09:31	58.40	40.40	30.07	27.18
14:10:01	58.40	42.80	30.07	27.65
14:10:31	58.30	41.90	30.07	25.98

003	068	076	058
005	055	086	047
017	050	102	045
015	053	085	051
017	055	071	049
019	050	129	047
019	068	111	061
020	073	090	062
024	065	091	057
026	066	128	057
028	069	075	063
028	066	161	058
032	083	193	071
036	092	107	081
059	078	149	070
050	082	165	069
051	092	181	077
053	097	185	082
055	107	183	086
058	107	232	081
062	122	248	066
066	134	179	075
068	121	094	091
077	096	162	075
084	093	131	079
088	093	140	078
085	100	096	080
083	085	062	067
081	069	058	056
081	057	069	048

335 deg (NNW) - running into the wind

50 deg (NE)

330 deg (NNW)

14:11:01	58.20	41.00	30.06	30.53					
14:11:31	58.20	40.00	30.07	28.46	080	051	078	050	
14:12:01	58.20	41.40	30.06	31.30					
14:12:31	58.30	39.70	30.07	29.71	080	056	114	052	
14:13:01	58.30	39.50	30.07	24.67					
14:13:31	58.30	40.20	30.07	23.16	079	061	150	063	
14:14:01	58.30	41.40	30.07	23.69					
14:14:31	58.30	40.40	30.07	18.51	077	079	132	072	
14:15:01	58.20	41.20	30.07	24.10					
14:15:31	58.20	37.80	30.07	15.93	076	079	217	061	
14:16:01	58.20	38.00	30.06	24.89					
14:16:31	58.30	39.20	30.06	31.20	071	098	203	074	
14:17:01	58.30	38.50	30.06	25.25					
14:17:31	58.30	38.10	30.05	35.28	068	110	209	092	
14:18:01	58.30	40.00	30.06	29.60					
14:18:31	58.20	40.70	30.05	30.99	067	122	190	100	
14:19:01	58.20	40.60	30.05	33.99					
14:19:31	58.20	38.70	30.05	34.39	067	133	229	098	
14:20:01	58.20	38.90	30.06	24.53					Arrive at Rt 2 bridge on So. River, start turn
14:20:31	58.20	40.50	30.06	25.99	069	142	110	092	End Westerly Run #2
14:21:01	58.20	40.70	30.08	11.04					
14:21:31	58.40	39.60	30.08	1.69	080	112	013	081	
14:22:00	58.90	36.80	30.09	0.89					145 deg (SE) - Reduce speed to 2000 RPM
14:22:29	59.50	37.50	30.09	1.16	083	089	014	065	
14:23:02	60.20	32.20	30.09	4.79					
14:23:31	60.70	31.20	30.08	1.87	087	071	010	051	
14:24:01	60.90	29.90	30.08	6.33					
14:24:31	61.20	32.20	30.08	1.15	083	040	016	042	
14:25:01	61.70	32.30	30.08	1.35					
14:25:32	62.00	31.20	30.08	.	076	032	012	033	
14:26:01	62.60	29.00	30.09	.					
14:26:30	63.00	32.10	30.08	1.14	069	030	013	022	
14:27:02	63.20	26.50	30.08	1.23					
14:27:31	63.20	26.90	30.08	5.11	058	027	008	024	
14:28:01	63.00	29.00	30.08	2.29					
14:28:31	63.00	29.70	30.08	9.12	045	013	008	022	
14:29:01	62.90	30.00	30.08	9.18					Trailing wind noticable
14:29:31	62.70	33.50	30.08	10.97	034	007	008	020	
14:30:01	62.60	28.80	30.08	10.20					
14:30:31	62.80	29.50	30.08	11.31	028	005	010	016	
14:31:01	62.80	32.30	30.08	12.22					
14:31:31	62.80	29.00	30.08	2.12	024	005	004	013	
14:32:01	62.80	31.40	30.08	13.32					
14:32:31	62.80	33.10	30.08	4.88	021	007	014	012	
14:33:01	62.90	32.90	30.08	3.81					
14:33:31	63.20	29.20	30.08	8.59	019	004	012	012	
14:34:01	63.30	33.20	30.07	10.23					180 deg (S) - Head for gas dock
14:34:31	63.20	31.90	30.07	2.95	018	004	018	012	
14:35:02	63.20	33.50	30.08	.					
14:35:31	63.40	31.70	30.08	.	014	005	029	014	
14:36:00	63.40	32.20	30.08	1.50					
14:36:31	63.30	30.50	30.08	2.32	011	013	041	014	
14:37:01	63.30	30.60	30.07	1.37					
14:37:31	63.40	28.90	30.07	1.46	009	019	068	015	220 deg (SW) - Into Selby Bay for gas
14:38:02	63.40	30.40	30.08	4.94					
14:38:31	63.40	31.30	30.08	3.19	009	039	081	015	
14:39:01	63.50	29.20	30.07	10.32					
14:39:31	63.40	30.70	30.07	28.49	010	039	076	012	
14:40:01	63.20	30.60	30.07	29.23					290 deg (WNW)

1:40:31	62.80	31.10	30.06	33.05	010	035	066	012
1:41:01	62.30	30.00	30.07	28.48				
1:41:31	62.00	29.90	30.07	20.24	011	034	039	014
1:42:01	61.80	29.50	30.07	24.19				
1:42:31	61.70	30.80	30.08	9.75	013	031	052	014
1:43:01	61.40	30.60	30.08	13.24				
1:43:31	61.10	31.10	30.08	13.28	016	025	047	015
1:44:01	60.80	31.50	30.08	11.45				
1:44:31	60.50	31.60	30.08	10.52	018	025	003	015
1:45:01	60.10	32.80	30.08	13.60				
1:45:31	59.90	30.60	30.08	10.24	020	017	002	014
1:46:01	59.70	32.40	30.08	9.12				
1:46:31	59.40	33.10	30.08	11.83	020	014	003	012
1:47:01	59.20	32.40	30.09	3.27				
1:47:31	59.00	34.40	30.08	7.52	020	014	003	010
1:48:01	58.70	35.10	30.08	14.94				
1:48:31	58.60	33.50	30.08	14.78	018	015	003	008
1:49:01	58.40	32.90	30.08	10.61				
1:49:31	58.20	33.60	30.08	6.77	017	015	003	007
1:50:01	58.10	35.10	30.08	12.46				
1:50:31	57.90	33.90	30.08	10.73	015	016	003	008
1:51:01	57.80	34.10	30.09	3.75				
1:51:31	57.70	34.80	30.08	7.97	014	018	003	007
1:52:01	57.60	33.60	30.08	9.25				
1:52:31	57.40	35.00	30.08	17.51	013	020	003	007
1:53:01	57.40	35.30	30.08	12.38				
1:53:31	57.30	34.10	30.08	11.16	013	019	003	008
1:54:01	57.20	34.50	30.09	10.28				
1:54:31	57.10	35.30	30.09	8.06	013	018	003	008
1:55:01	57.00	36.10	30.08	5.92				
1:55:31	56.90	35.10	30.09	8.47	013	019	003	006
1:56:01	56.80	35.20	30.09	10.25				
1:56:31	56.80	36.50	30.09	9.70	013	018	003	007
1:57:01	56.70	37.00	30.09	4.94				
1:57:31	56.70	35.20	30.09	13.59	013	018	003	007
1:58:01	56.70	35.80	30.09	10.02				
1:58:31	56.60	36.00	30.08	15.94	013	018	002	007
1:59:01	56.60	35.80	30.08	15.93				
1:59:31	56.60	35.20	30.09	9.63	013	017	003	006
5:00:01	56.50	35.30	30.09	14.74				
5:00:31	56.50	36.50	30.08	14.19	012	015	008	006
5:01:01	56.50	35.40	30.09	10.56				
5:01:31	56.50	35.50	30.09	14.21	012	015	031	007
5:02:01	56.50	36.40	30.09	3.36				
5:02:32	56.60	35.00	30.09	9.10	012	016	020	011
5:03:01	57.00	33.30	30.09	4.78				
5:03:31	57.80	32.90	30.09	1.69	011	016	022	057
5:04:01	58.80	29.50	30.09	4.65				
5:04:31	59.60	29.00	30.10	.	011	015	021	032
5:05:00	60.50	29.30	30.09	1.28				
5:05:31	60.70	29.80	30.09	3.02	011	014	023	016
5:06:01	60.90	30.80	30.09	3.33				
5:06:31	61.10	29.90	30.09	10.31	011	012	010	013
5:07:01	61.10	33.80	30.09	4.10				
5:07:32	60.90	34.70	30.09	1.64	011	010	011	010
5:08:01	60.80	35.40	30.09	2.36				
5:08:31	60.70	35.60	30.09	1.72	011	014	020	015
5:09:01	60.80	36.50	30.09	5.41				
5:09:32	60.80	33.90	30.09	6.83	010	018	017	019
5:10:02	61.00	31.20	30.09	3.99				

275 deg (MWR) - @ gas dock, Stop engines

Bilge blowers on

Restart Engines

100 deg (E)

5:10:32	61.30	29.90	30.09	7.54	010	014	008	019	
5:11:02	61.60	32.50	30.09	4.07					
5:11:32	61.90	32.80	30.09	5.59	010	009	007	014	
5:12:01	62.30	29.70	30.09	8.77					140 deg (SE)
5:12:31	62.60	31.30	30.09	9.80	011	007	009	011	
5:13:01	62.90	31.60	30.09	8.97					
5:13:32	63.10	32.00	30.09	7.63	009	005	006	009	
5:14:01	63.30	30.20	30.09	12.40					
5:14:32	63.50	30.10	30.09	10.14	007	004	012	008	
5:15:02	63.60	31.20	30.08	1.50					190 deg (S)
5:15:31	63.60	33.80	30.08	6.12	006	003	022	009	
5:16:02	63.50	33.10	30.09	2.54					Bilge blowers off
5:16:31	63.30	35.40	30.09	6.06	005	012	021	018	
5:17:01	63.10	33.30	30.08	12.40					
5:17:31	63.00	31.60	30.09	3.82	004	018	020	015	
5:18:01	62.80	35.60	30.08	8.77					
5:18:31	62.90	35.00	30.08	8.27	006	019	018	013	
5:19:01	62.30	35.10	30.08	4.78					
5:19:31	62.10	36.90	30.08	1.22	008	020	023	017	
5:20:01	61.90	36.60	30.09	11.12					210 deg (SSW) - Starboard beam wind
5:20:31	61.90	34.40	30.08	11.76	011	022	042	014	
5:21:01	61.90	33.60	30.08	17.20					
5:21:31	61.80	36.60	30.09	11.95	012	027	040	009	
5:22:01	61.70	38.20	30.09	10.01					
5:22:31	61.70	36.60	30.08	13.53	013	036	038	010	
5:23:01	61.70	35.90	30.09	9.02					
5:23:31	61.70	37.80	30.09	13.91	016	035	031	012	
5:24:01	61.70	35.90	30.09	12.04					
5:24:31	61.70	36.40	30.09	13.92	018	034	033	012	
5:25:01	61.70	35.40	30.09	14.89					
5:25:31	61.60	36.00	30.09	11.40	020	032	041	011	
5:26:02	61.50	34.70	30.08	14.09					
5:26:32	61.50	37.30	30.09	17.10	020	033	067	010	
5:27:01	61.30	38.90	30.08	28.11					
5:27:32	61.30	38.10	30.08	35.03	021	040	095	011	
5:28:02	61.10	40.60	30.08	32.84					270 deg (W)
5:28:32	61.00	40.10	30.08	27.35	021	054	088	016	
5:29:01	60.90	39.20	30.09	26.85					
5:29:32	60.70	39.00	30.09	26.03	022	056	097	019	
5:30:01	60.70	40.70	30.08	27.91					
5:30:32	60.50	39.70	30.09	26.71	023	063	082	022	
5:31:01	60.40	38.70	30.09	28.94					
5:31:32	60.20	37.60	30.09	30.22	024	057	084	028	
5:32:01	60.10	38.20	30.09	33.03					265 deg (W) - Speed at 2400 RPM
5:32:32	60.10	38.60	30.09	32.61	026	054	083	026	
5:33:01	60.00	35.80	30.09	29.71					
5:33:32	59.90	38.00	30.09	31.69	030	056	081	028	
5:34:02	59.80	39.90	30.09	30.00					
5:34:32	59.70	37.70	30.09	30.86	029	055	089	027	
5:35:02	59.60	40.10	30.09	29.79					
5:35:31	59.50	39.20	30.09	25.73	031	057	071	027	
5:36:01	59.40	39.80	30.09	30.77					
5:36:32	59.30	39.20	30.10	29.46	031	051	082	029	
5:37:01	59.20	38.50	30.10	30.48					
5:37:31	59.20	39.00	30.10	31.02	031	055	096	026	
5:38:02	59.10	39.80	30.10	23.31					
5:38:31	59.10	39.80	30.10	25.52	032	057	101	025	
5:39:01	59.10	37.60	30.10	29.07					240 deg (WSW)
5:39:32	59.20	36.60	30.10	21.46	035	069	054	028	
5:40:01	59.20	34.50	30.10	25.58					

15:40:32	59.30	33.90	30.10	27.45	037	061	063	029
15:41:01	59.40	33.40	30.11	18.20				
15:41:31	59.90	35.60	30.11	9.21	038	043	046	018
15:42:02	59.60	35.90	30.11	4.53				
15:42:31	59.60	34.50	30.11	2.09	038	045	035	019
15:43:01	59.50	35.20	30.11	9.56				
15:43:31	59.60	34.40	30.11	10.02	040	033	060	014
15:44:01	59.70	34.00	30.11	7.21				
15:44:31	59.80	33.90	30.11	7.69	040	032	024	010
15:45:01	59.80	33.70	30.11	2.34				
15:45:31	59.80	32.60	30.11	1.33	040	022	015	013
15:46:03	59.70	34.80	30.12	.				
15:46:31	59.80	34.80	30.12	.	040	025	045	020
15:47:00	59.90	33.90	30.12	.				
15:47:30	59.90	32.40	30.11	7.60	040	023	014	019
15:48:01	59.80	32.70	30.11	2.19				
15:48:32	59.90	32.80	30.12	.	038	018	098	024
15:49:01	59.90	33.70	30.11	12.42				
15:49:31	59.50	34.50	30.11	11.32	037	054	104	034
15:50:01	59.40	33.70	30.11	14.09				
15:50:31	59.20	35.70	30.11	15.91	034	038	004	034
15:51:01	59.00	35.40	30.11	16.39				
15:51:31	58.80	34.50	30.11	8.00	031	034	002	034
15:52:01	58.60	35.10	30.11	14.47				
15:52:31	58.30	36.00	30.11	19.12	030	021	002	031
15:53:01	58.10	36.20	30.11	10.32				
15:53:31	57.90	36.40	30.11	15.28	028	015	002	029
15:54:01	57.70	36.00	30.11	12.11				
15:54:31	57.60	36.40	30.11	9.56	028	019	002	028
15:55:01	57.40	36.30	30.11	17.37				
15:55:31	57.40	35.80	30.11	12.31	026	011	002	026
15:56:01	57.20	36.30	30.11	11.13				
15:56:31	57.00	37.80	30.11	10.57	025	011	002	026
15:57:01	57.00	38.30	30.11	12.03				
15:57:31	56.90	38.50	30.11	9.20	023	007	002	026
15:58:01	56.80	38.50	30.11	12.12				
15:58:31	56.70	37.60	30.11	11.39	022	009	002	025
15:59:01	56.60	38.50	30.11	11.22				

Slow speed - maneuvering in YC area

at dock
Engines off

Totals:

AVG :	59.33	37.87	30.10	13.39	32	40	62	28
MIN :	51.60	21.70	30.05	.	-1	05	03	04
MAX :	66.20	59.70	30.15	39.28	178	255	407	133
SD :	3.00	6.58	0.02	(8.95)	40	504	883	313

note: wind indicator did not measure
negative wind. Incidents of a positive
trailing wind indicated by " . "

Chesapeake Bay Coast Guard Boat Tests - December 10, 1990

Variable	n	Mean	Std Dev	Minimum	Maximum
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Morning Easterly Run 10:08:01 - 10:17:31

TEMP	20	63.73	0.73	62.70	65.10
RH	20	33.18	1.14	30.50	34.90
BARO	20	30.11	0.002	30.11	30.12
KNOTS	20	10.57	1.71	6.53	12.52
CO1	10	3.40	0.52	3.00	4.00
CO2	10	7.50	2.94	4.00	13.00
CO3	10	11.80	3.22	7.00	18.00
CO4	10	4.20	1.40	3.00	8.00
MINS	20	4.76	2.96	0.00	9.50

Morning Westerly Run 10:18:31 - 11:20:01

TEMP	125	59.36	1.40	56.70	62.60
RH	125	40.86	4.92	34.00	52.90
BARO	125	30.10	0.01	30.08	30.12
KNOTS	125	18.35	6.53	2.15	31.67
CO1	62	84.34	62.87	2.00	178.00
CO2	61	116.15	69.30	5.00	255.00
CO3	60	203.68	110.29	22.00	407.00
CO4	61	72.52	46.76	5.00	254.00
MINS	124	31.00	18.19	0.00	62.00

Afternoon Easterly Run 12:55:00 - 13:36:31

TEMP	84	58.82	1.94	56.80	62.30
RH	84	44.74	6.11	33.60	54.10
BARO	84	30.08	0.01	30.07	30.09
KNOTS	83	9.37	3.53	1.08	14.26
CO1	42	2.10	2.64	0.00	11.00
CO2	42	2.24	1.16	1.00	6.00
CO3	42	6.64	8.99	3.00	61.00
CO4	42	4.64	0.88	3.00	7.00
MINS	84	20.77	12.19	0.00	41.51

Afternoon Westerly Run 13:39:31 - 14:20:01

TEMP	82	56.62	1.68	54.50	58.80
RH	82	46.51	6.30	37.80	59.70
BARO	82	30.07	0.01	30.05	30.08
KNOTS	82	25.99	4.90	15.56	35.28
CO1	41	50.22	28.13	2.00	88.00
CO2	41	81.44	24.51	48.00	134.00
CO3	41	136.80	52.78	58.00	248.00
CO4	41	66.93	15.11	44.00	100.00
MINS	82	20.25	11.91	0.00	40.50